

A. ORTIZ.

COMPOUND METAL BODY AND METHOD OF MAKING THE SAME.

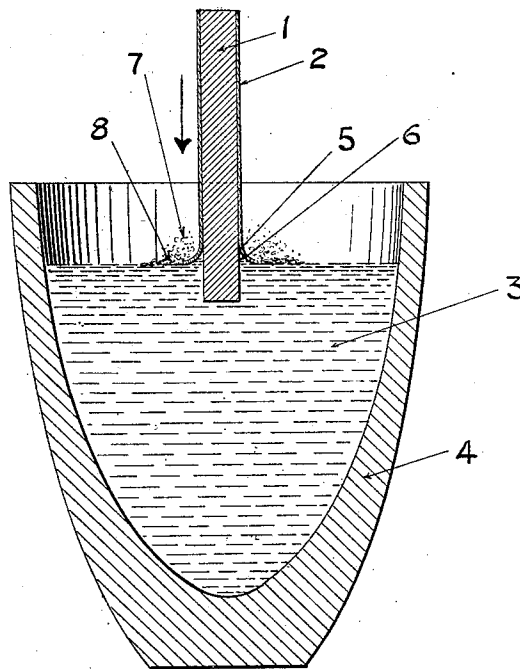
APPLICATION FILED DEC. 23, 1914. RENEWED AUG. 9, 1921.

1,409,017.

Patented Mar. 7, 1922.

6 SHEETS—SHEET 1.

Fig. 1.



WITNESSES:

L. G. Guehl.
E. B. Blumling

INVENTOR.

Aracelis Ortiz
BY *Mathewes Dymos & Parnell*
ATTORNEYS.

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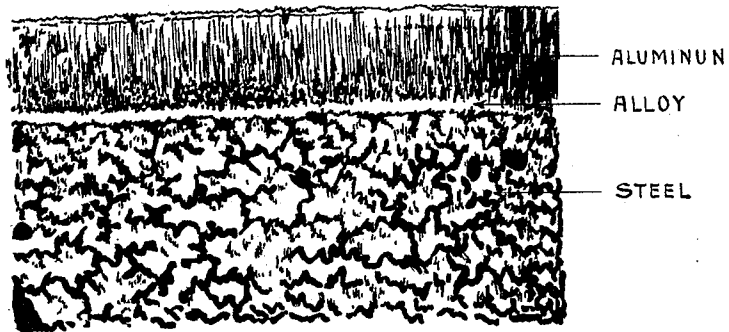
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6 SHEETS—SHEET 2.

Fig. 2.



WITNESSES:

L. A. Guehl
E. B. Blumling

INVENTOR.

Anselmo Ortiz
BY *Bartholomew Dymally & Associates*
ATTORNEYS.

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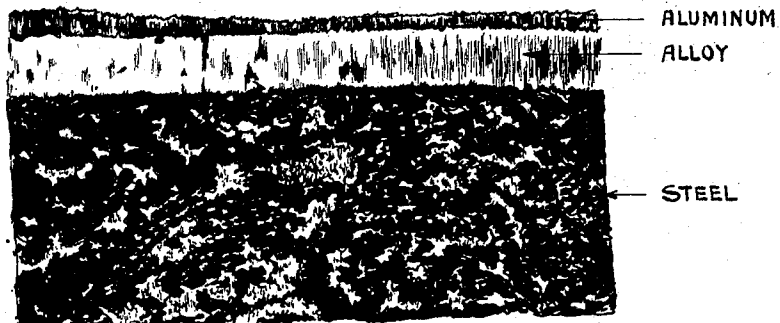
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6 SHEETS—SHEET 3.

Fig. 3.



WITNESSES:

L. W. Greckl.
G. B. Blumling

INVENTOR.

Aurelio Ortiz
BY *DeKenne Hayes & Bonnell*
ATTORNEYS.

A. ORTIZ.

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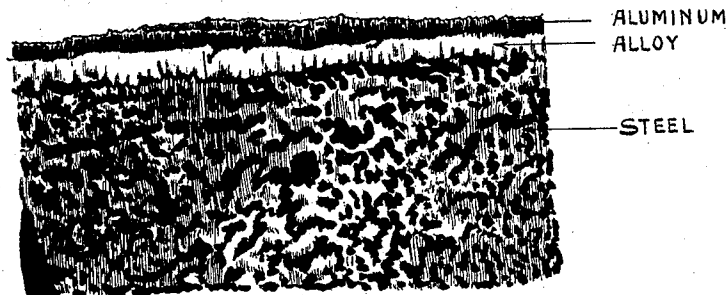
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6 SHEETS—SHEET 4.

Fig. 4.



WITNESSES:

L. A. Guehl
G. B. Blinn

INVENTOR.

Anselmo Ortiz
BY *Madame Rymes & Associates*
ATTORNEYS.

A. ORTIZ.

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6 SHEETS—SHEET 5.

Fig. 5.



WITNESSES:

L. A. Seidl
G. B. Blinn

INVENTOR.

Aurelio Ortiz
BY *Patented Repro & Pomeroy*
ATTORNEYS.

A. ORTIZ.

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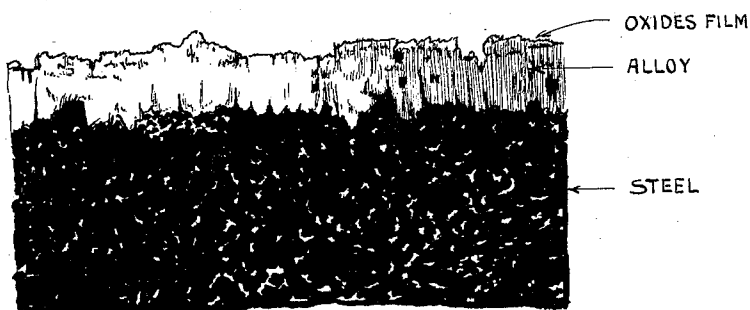
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6 SHEETS—SHEET 6.

Fig. 6.



WITNESSES:

L. A. Siehl
G. B. Blum

INVENTOR.

Anselmo Ortiz
BY *Robert R. Byrnes & Associates*
ATTORNEYS.

UNITED STATES PATENT OFFICE.

ANSELMO ORTIZ, OF BAYONNE, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO
GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

COMPOUND METAL BODY AND METHOD OF MAKING THE SAME.

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Specification of Letters Patent.

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Application filed December 23, 1914, Serial No. 878,696. Renewed August 12, 1921. Serial No. 491,012.

To all whom it may concern:

Be it known that I, ANSELMO ORTIZ, a subject of the King of Spain, residing at Bayonne, in the county of Hudson and State of New Jersey, have invented a new and useful Improvement in Compound Metal Bodies and Methods of Making the Same, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a vertical section illustrating the coating step of my process; and

Figures 2 to 6, inclusive, are cross sections showing the different types of product or compound metal article.

My invention relates to the coating of ferrous metal with other non-ferrous metals, and particularly to the coating of ferrous metal with aluminum or aluminum alloy.

Many attempts have been made to provide a ferrous metal with a uniform continuous coating of aluminum, but these attempts have been unsuccessful. In one proposed process for the purpose, the ferrous metal has been dipped in a bath of molten aluminum at a temperature several hundred degrees above the melting point of aluminum, such process being based upon a supposed lack of affinity between the ferrous metal and the aluminum at temperatures nearer the melting point of aluminum. Other attempts have been made by providing the ferrous metal with a preliminary film or wash coating of a metal other than the coating metal. Both these methods have been unsuccessful, the first method causing the metal to attack the iron and produce irregular coatings of widely varying form and composition and partly destroying the outline of the article; while the latter one produces a coating, not of aluminum, but of an alloy of aluminum and the wash metal. In the latter case, a coating of pure aluminum could only be obtained by successive dippings in a series of baths, making the process commercially impracticable. Salts of heavy metals have also been used for coating the ferrous metals before dipping in molten aluminum, but in such case salts are brought into the molten aluminum which practically prevent the contact be-

tween the metals and thus a complete and continuous coating is not obtained. The salts of the heavy metals used also react with the aluminum, the result being a coating not of aluminum, but of an alloy.

I have discovered a method by which ferrous articles can be given an aluminum coating in the form of a dense, poreless layer united to the ferrous metal by an intermediate layer of iron aluminum alloy, the aluminum being also uniform, continuous and of a constant characteristic form and composition.

My process is based upon the discovery that if a cleaned ferrous article is lowered into a bath of molten aluminum at such a rate and under such conditions that the successive portions of the ferrous article are successively wetted by the molten aluminum, as evidenced by the presence of an upwardly projecting meniscus at the juncture between the ferrous article and the bath, a uniform, continuous aluminum coating is obtained of a constant characteristic form and composition. The same process may be employed for coating ferrous metals with other non-ferrous metals or alloys, and the meniscus must be constantly maintained by so regulating the speed of feeding the article in the molten bath that the meniscus will not be destroyed or inverted. The presence of this meniscus will cause oxides or foreign compounds at the juncture to be washed away from the contacting surfaces, in such a way that an actual "diffusion joint" is obtained. By the term "diffusion joint" in this specification, I mean the joint which occurs when two metals are brought into contact and interpenetration of one into the other taken place, or when mutual interpenetration occurs. Neither material need be at or above its melting point, though either or both may be.

I will now describe the form of my invention as applied to the coating of iron or steel articles with aluminum. First, the ferrous article should be cleaned as thoroughly as practicable from oxides or other impurities on the surface, as for example, by dipping the article in a fifty per cent solution of ammonium citrate for a proper period of time. After withdrawal from the

solution, the article may be washed with water and dried.

The aluminum is melted, preferably in either an inert or reducing atmosphere, such as nitrogen, hydrogen, hydrocarbon, etc. At least, the reducing atmosphere is preferably present at the time the ferrous article is dipped in the molten bath, since this reducing atmosphere at the operating temperature tends to prevent the formation of oxides on the surface of both metals and also to reduce traces of oxides which may be carried by the ferrous article.

The surface of the aluminum bath being as clean as practicable, the ferrous article is lowered gradually in the molten aluminum bath, at such a rate that its successive portions are wetted by the molten metal. The evidence of this continuous wetting lies in the presence of an upwardly projecting meniscus at the juncture between the ferrous article and the bath, and the rate of feeding must be such as to maintain this meniscus so that it is neither destroyed nor inverted. The presence of this meniscus proves the wetting and will cause oxides or foreign compounds at the juncture to be removed and washed away from the contacting surface.

Instead of using an inert or reducing atmosphere, during the dipping step, I may eliminate this by using a flux for the ferrous article, although I may use both the flux and the inert or reducing atmosphere.

If a flux is used, it should be one which will melt at a temperature below the melting point of aluminum, this melting flux aiding in washing away and removing the impurities at the meniscus joint. The flux should be stable and uniformly adherent to the surface of the ferrous article, and many fluxes may be used for this purpose within the scope of my invention. I may use for this purpose a flux composed of a mixture of potassium chloride, sodium chloride and zinc chloride. The cleaned ferrous article may be dipped in the molten flux, so that its surface is wetted and covered thereby and may then be removed from the flux bath and dipped in the bath of molten aluminum, whose surface has been previously cleaned of impurities, by the maintaining of the meniscus, as above described.

In the drawings, referring to Figure 1, the dipping step is here illustrated with a ferrous article having a flux coating. In this figure, the ferrous article 1, coated with a layer of flux 2, is being lowered gradually into the bath of molten aluminum 3 within the vessel 4. The temperature of the aluminum may range from 650 degrees C. to 1100 degrees C., and as soon as the surface of contact reaches a temperature of 650 degrees C., the ferrous article is wetted by the aluminum at 5, and the meniscus appears, as shown at

6. The melting flux flows along this meniscus, the zinc chloride volatilizing, as indicated at 7. The remaining chlorides of the flux mixed with impurities flow off from the meniscus joint, as shown at 8.

Under these conditions, any oxides or foreign substances are floated off at the meniscus joint, the ferrous article is continuously wetted, and a perfect and complete contact between both metals is secured.

When one article has been dipped in the bath, the surface of the bath may be cleaned of impurities, the article taken out and another article dipped.

Under these conditions, the iron and molten aluminum unite with a diffusion joint, consisting of a constant and definite aluminum alloy of characteristic structure and composition. This alloy forms a continuous homogeneous coating on the surface of the ferrous metal, uniting the ferrous metal to a surface layer of pure aluminum, which lies upon the alloy. This aluminum coating is continuous, compact, dense and bright.

The character of the coating and the joint may be varied somewhat by varying the temperatures and the period during which the ferrous metal is held in the bath. While the formation of the compound coating takes place through a considerable temperature range, as above described, the thickness of the layers may be varied both individually and relatively. If the temperature of the aluminum is between 650 degrees C. and 700 degrees C., a coating is obtained which for almost its entire thickness consists of aluminum, the intermediate diffusion joint of alloy being very thin. Such a structure is shown in Figure 2. If the temperature of the molten aluminum is above 800 degrees C., a coating is produced, in which the thickness of the alloy layer is greater, such a coating being shown in Figure 3.

Again, the time element has an influence on the coating. Thus, if ferrous metal is dipped in molten aluminum at from 700 degrees C. to 800 degrees C., and allowed to stand in such a bath for only a short time, a thinner coating of the same composition as above is produced, such as shown in Figure 4. If the same ferrous metal is allowed to stand in the bath of from 700 degrees C. to 800 degrees C., for a longer time, the thickness of the alloy portion is increased, such a structure being shown in Figure 5.

Another feature of my invention lies in modifying the coating thus obtained. I have found that by continued high temperature heating of the article produced by my process, the alloy coating or diffusion joint will be increased in thickness, and this increase may be carried to a point where no coating of aluminum remains, all of the aluminum having been converted into the alloy. If this heating is carried out in the

open air, the alloy finally oxidizes on its outer surface, giving an article such as shown in Figure 6.

Even under the wide range of temperatures above described and with wide variations in time of treatment, the same alloy is formed at the juncture joint, this alloy being a chemical compound having the formula FeAl_3 .

The advantages of my invention will be obvious to those skilled in the art, since a simple, easily operated process is provided, by which ferrous metal may be given an aluminum coating under commercial conditions and at relatively small expense. A large field is thus opened up for aluminum-coated ferrous materials, which has heretofore been closed on account of the impossibility of giving iron or steel a proper coating.

The process may be applied to other metals than aluminum and may also be applied to aluminum alloys. The molten aluminum may be moved upwardly over the ferrous article, instead of lowering the ferrous article into the bath.

Many changes may be made in the steps of cleaning the ferrous material and in the fluxes, if such are used, and other variations may be made without departing from my invention, since I consider myself the first to discover that by maintaining an upwardly projecting meniscus between a fairly well cleaned ferrous body and a molten non-ferrous bath, I can produce a uniform, continuous coating united by a diffusion joint.

I claim:

1. The method of coating a ferrous body with a non-ferrous metal, consisting in successively contacting the ferrous body with a molten non-ferrous metal at a rate which continuously maintains an upwardly projecting meniscus.

2. The method of coating a ferrous body with aluminum consisting in successively contacting the ferrous body with molten aluminum at a rate which continuously maintains an upwardly projecting meniscus between the ferrous body and the molten aluminum bath.

3. The method of producing a compound body of a ferrous metal base and aluminum iron alloy and aluminum, consisting in contacting the successive portions of the ferrous article with molten aluminum and successively wetting all parts of the article as evidenced by the presence of an upwardly projecting meniscus at the joint.

4. The method of coating a ferrous body with a non-ferrous metal, consisting in cleaning the ferrous body and successively contacting it with a molten non-ferrous metal at a rate which continuously maintains an upwardly projecting meniscus.

5. The method of coating a ferrous body

with a non-ferrous metal, consisting in cleaning the ferrous body, successively contacting it with a molten non-ferrous metal at a rate which continuously maintains an upwardly projecting meniscus, and protecting the ferrous body from oxidizing influences during the immersion.

6. The method of coating a ferrous body with aluminum, consisting in treating the ferrous body, successively contacting it with molten aluminum at a rate which continuously maintains an upwardly projecting meniscus, and protecting the ferrous body from oxidizing influences during immersion.

7. The method of coating a ferrous body with aluminum, consisting in protecting the ferrous body with a flux, and then immersing the same in an aluminum bath at a rate which continuously maintains an upwardly projecting meniscus.

8. The method of coating a ferrous body with a non-ferrous metal, consisting in successively contacting the ferrous body with a molten non-ferrous metal at a rate which continuously maintains an upwardly projecting meniscus in the presence of a non-oxidizing atmosphere.

9. The method of producing a compound metal body, consisting in immersing a ferrous body in a bath of molten aluminum at a rate which continuously maintains an upwardly projecting meniscus, removing the article from the bath and then heating said body at a high temperature to force at least a part of the aluminum of the external aluminum coating into an iron aluminum alloy.

10. The method of treating a ferrous body previously coated with aluminum united thereto by a diffusion joint, which consists in heating the same at a high temperature and hereby forcing at least a part of the aluminum coating into iron aluminum alloy.

11. The method of treating a ferrous body having a previously formed aluminum coating united thereto by an iron aluminum alloy joint, consisting in heating the same at a high temperature, and increasing the depth of said iron aluminum joint.

12. A process of treating metal which consists in coating the metal by contact with molten aluminum, removing the metal thus coated from the molten aluminum and during this step bringing the metal to the melting point of the aluminum, and in then subjecting said coated metal to heat under suitable conditions considerably higher than the melting point of aluminum for such time that a compound of the two is obtained which is highly refractory and substantially non-oxidizable.

13. A process of treating steel, iron and like ferric compounds which consists in coating such metal by contact with molten aluminum, while and during this step bringing the metal to at least the melting point of the

aluminum, removing the metal thus coated from the molten aluminum, and in then subjecting the said coated metal to heat under suitable conditions considerably higher than
5 the melting point of aluminum, for such time that a highly refractory and substantially non-oxidizable compound of the two is obtained.

14. A process of treating metal which consists in coating the metal by contact with aluminum and during this step bringing the metal to the melting point of the aluminum, removing the metal thus coated from the molten aluminum and in then subjecting the
15 said coated metal to heat under suitable conditions of such degree higher than the melting point of aluminum as to cause the aluminum to alloy with the metal in a product that is highly refractory and substantially non-oxidizable.
20

15. A metal product consisting of a ferric compound and aluminum combined by bringing the metal into contact while the aluminum is molten and the other metal is

at least at the melting point of the aluminum 25 before union occurs, removing the metal thus coated from the molten aluminum, and thereafter subjecting the coated metal to such temperature under suitable conditions that a highly refractory and substantially 30 non-oxidizable product results.

16. The method of producing a compound metal body, consisting in immersing a metal body in a bath of molten aluminum at a rate which continuously maintains an upwardly 35 projecting meniscus, withdrawing the body and allowing the coating to set, and then heating the compound metal body at a high temperature to force at least a part of the aluminum coating into an iron aluminum 40 alloy.

In testimony whereof, I have hereunto set my hand.

ANSELMO ORTIZ.

Witnesses:

A. N. LOWES,
E. G. BASHORE.