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PROCESS OF CEMENTATION

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This invention relates to the coating and impregnating of metals, particularly iron and steel, with other metals by a process of cementation.

It has heretofore been proposed to coat a metal by processes of cementation wherein the metal to be coated is heated in contact with the coating metal in powdered form. Under these prior proposals, however, extremely anhydrous conditions, high temperatures, and special provisions for rigid reducing atmospheres were necessary as well as long periods of heating. Other objections and disadvantages were also inherent in these prior processes which, coupled with the negligible degree of penetration of the coating metal into the grain structure of the foundation metal, rendered such practices as well as the resultant products of little or no practical or commercial value.

According to the present invention, coating and impregnation are obtained at relatively low temperatures and with no necessity for the maintenance of the extreme conditions above outlined. Furthermore, the results are superior in that the depth of the coating and impregnation or case is substantial and of such character as to impart to the resultant product highly desirable and advantageous characteristics such as superior and lasting corrosion and scale resisting properties and luster or color, rendering the invention one of wide application and usefulness.

I have discovered that when organic salts of the desired coating and impregnating metals such as the formates, oxalates, acetates, etc. are packed about a foundation metal, such as iron and steel for example, and the whole heated in a closed receptacle to a temperature below the melting point of either metal, the salts decompose, liberating the metal constituent of the salt which in turn penetrates or enters the surface layer of the foundation metal and also forms a coating layer over the surface of such metal, these layers together constituting what may aptly be called a case comprised of substantially pure metal on the outside with a gradation inward of alloy decreasing in richness of coating and impregnating metal content from the surface to the interior of the foundation metal. By varying the time and temperature of the treatment, the thickness or depth of the case may be varied.

By way of example of the practice of the process, a mixture of 30 grams of nickel oxalate and one gram of iron chloride flux was packed about a low carbon steel article in a large tube closed at one end. This was inserted in a vertical electric furnace and the temperature raised

to approximately 1500° F. and held there for four hours. Nitrogen gas was introduced into the open end of the tube to displace the air. The article, after this treatment and upon cooling, showed a nickelized case under the microscope with pure nickel on the outside and a gradual decline of the nickel content to the inside margin of the case. On etching a section of the article in dilute sulphuric acid, the case was plainly noticeable without magnification. It was from .005" to .025" in thickness. There was no sharp line between the case and core but a gradual change from the pure nickel on the outside to iron in the core, the inward portion of the case being a nickel iron alloy. Thus a case is formed which is firmly locked in the steel and is, in fact, an integral part of it. Crushing the impregnated article failed to show any cracking, separation, or other damage or impairment to the case.

If, in the above example, copper, chromium, or manganese oxalate were substituted for the nickel oxalate, the coating and impregnating case would be of copper, chromium, or manganese, and should it be desired to coat and impregnate the iron or steel with an alloy of two or more of these metals, a mixture of the organic salts of such metals would be used.

I have further discovered that in carrying out the process, the organic salts on decomposing generate inert and reducing gases such as carbon monoxide, carbon dioxide and hydrogen which protect the iron or steel from the air throughout the treatment, although under some conditions it may be found desirable to augment this protection by the addition of inert or reducing gases such as nitrogen or hydrogen from some outside source as in the above example. A quantity of some suitable fluxing material such as ferric-chloride or copper-chloride added to or mixed with the organic salt appears to expedite the penetration, although the process is entirely practical and workable without the use of an outside inert gas to augment the natural inert or reducing atmosphere generated and provided by the organic salts on heating. In fact, excellent results have been obtained by using merely the commercial organic salts and a flux and luting the receptacle to prevent oxidation. Metals other than iron or steel can be treated in a similar manner with similar results and organic salts of the desired impregnating metals other than the oxalates, formates, and acetates may be used, the chief requirement in this regard being that the selected salt be readily decomposable under heat to give off the desired coating and impreg-

nating metal in atomic fineness and at the same time generate an inert or reducing gas which will protect the foundation metal from the air during the treatment.

5 In carrying out the process, the organic salt decomposes, liberating the impregnating metal in atomic fineness which is many times finer than it is possible to grind the metal. The impregna-
10 tion of the metal in this form into the foundation metal proceeds with greater ease and rapidity and to a greater and more concentrated extent than under prior practices. The actual penetration is plainly shown by photomicrographs where it can be seen along and around
15 the grain boundaries of the foundation metal, and doubtless the impregnating metal also enters the grains themselves to form a solid solution which would not show in a photomicrograph because it would have the same grain structure as the
20 original ferrite. Along the grain boundaries the impregnating metal appears to be in a substantially pure state, while the grains themselves are of an alloy of the foundation and impregnating metals. Such alloy produced by my process may
25 be termed a cementation alloy as distinguished from an alloy produced by fusion.

I claim:

1. The process of coating and impregnating the surface layer of one metal with another metal
30 which consists in heating the first-named metal under non-oxidizing conditions in contact with an organic salt of a second-named metal at a temperature below the melting point of either of
35 said metals, said organic salt being characterized by the ability to yield inert and reducing gases such as carbon dioxide, carbon monoxide and hydrogen, when decomposed as a result of said heating.

2. The process of coating and impregnating the surface layer of one metal with another metal
40 which consists in heating the first-named metal under non-oxidizing conditions in contact with an organic salt of the second-named metal such as the oxalate, formate, or acetate thereof at a temperature below the melting point of either of said
45 metals, said organic salt being characterized by the ability to yield inert and reducing gases such as carbon dioxide, carbon monoxide and hydrogen, when decomposed as a result of said heating.

3. The process of coating and impregnating the surface layer of iron or steel with nickel which consists in heating the iron or steel under non-oxidizing conditions in contact with an organic
50 salt of nickel such for example as nickel-formate, nickel-oxalate, or nickel-acetate to a temperature at which the salt decomposes, said salt being characterized by the ability to yield inert and
55 reducing gases such as carbon dioxide, carbon monoxide and hydrogen, when decomposed, liberating the nickel content thereof in the form of infinitesimally small particles which combine
60 with the iron or steel by adhesion, intergranular penetration, and cementation.

4. The process of coating and impregnating the surface layer of iron or steel with chromium which consists in heating the iron or steel under non-oxidizing conditions in contact with an organic
65 salt of chromium such for example as chromium-formate, chromium-oxalate, or chromium-acetate to a temperature at which the salt decomposes, said salt being characterized by the ability to yield inert and reducing gases such as
70 carbon dioxide, carbon monoxide and hydrogen, when decomposed, liberating the chromium content thereof in the form of infinitesimally small
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particles which combine with the iron or steel by adhesion, intergranular penetration, and cementation.

5. The process of coating and impregnating the surface layer of iron or steel with copper
5 which consists in heating the iron or steel under non-oxidizing conditions in contact with an organic salt of copper such for example as copper-formate, copper-oxalate, or copper-acetate to a temperature at which the salt decomposes, said
10 salt being characterized by the ability to yield inert and reducing gases such as carbon dioxide, carbon monoxide and hydrogen, when decomposed, liberating the copper content thereof in the form of infinitesimally small particles which
15 combine with the iron or steel by adhesion, intergranular penetration, and cementation.

6. A cementation compound for the treatment of iron or steel to provide the latter with a coating and impregnation in the form of a case of
20 non-oxidizing and corrosion resisting metal, consisting of an organic salt of the latter metal decomposable under heat, said salt being characterized by the ability to yield the metal constituent thereof in atomic fineness and inert and
25 reducing gases such as carbon dioxide, carbon monoxide and hydrogen.

7. A cementation compound for the treatment of iron or steel to provide the latter with a coating and impregnation in the form of a case of
30 non-oxidizing and corrosion resisting metal, consisting of an organic salt of the latter metal decomposable under heat, said salt being characterized by the ability to yield the metal constituent thereof in atomic fineness and an inert gas
35 which protects the iron or steel from the air during the treatment.

8. A cementation mixture for the treatment of iron or steel to provide the latter with a coating and impregnation in the form of a case of
40 non-oxidizing and corrosion resisting metal, consisting of an organic salt of the latter metal decomposable under heat, and a small quantity of fluxing material, said salt being characterized by the ability to yield the metal constituent thereof
45 in atomic fineness and an inert gas.

9. A cementation mixture for the treatment of iron or steel to provide the latter with a coating and impregnation in the form of a case comprised of an alloy of two or more non-oxidizing and corrosion
50 resisting metals, which mixture consists of organic salts of the latter metals decomposable under heat, said salts being characterized by the ability to yield the metal constituents thereof in atomic fineness and an inert gas.
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10. A cementation mixture for the treatment of iron or steel to provide the latter with a coating and impregnation in the form of a case comprised of an alloy of two or more non-oxidizing and corrosion
60 resisting metals, which mixture consists of organic salts of the latter metals decomposable under heat, and a small quantity of fluxing material, said salts being characterized by the ability to yield the metal constituent thereof in atomic fineness and inert and reducing gases
65 such as carbon monoxide, carbon dioxide and hydrogen.

11. The process of coating and impregnating the surface layer of one metal with an alloy of
70 two or more metals which consists in heating the first-named metal under non-oxidizing conditions in contact with organic salts of the other metals at a temperature below the melting point of any of said metals, said salts being characterized by
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the ability to decompose under heat to yield inert and reducing gases.

12. The process of coating and impregnating the surface layer of one metal with another metal which consists in heating the first-named metal under non-oxidizing conditions in contact with a heat decomposable salt of the second-named metal, said salts being characterized by the ability to yield inert and reducing gases and to liberate the metallic constituent thereof in the form of infinitesimally small particles which combine with the first-named metal to form a case of substantially pure metal on the outside and a cementation alloy of the two metals on the inside.

13. The process of coating and impregnating

the surface layer of iron or steel with a metal of the group consisting of chromium, nickel, copper and manganese which consists in heating the iron or steel under non-oxidizing conditions in contact with an organic salt of an acid of the group consisting of formic acid, oxalic acid and acetic acid of the desired metal of said first named group to a temperature at which the salt decomposes, said salts being characterized by the ability to yield inert and reducing gases when decomposed, liberating the metal content thereof in the form of infinitesimally small particles which combine with the iron or steel by adhesion, intergranular penetration, and cementation.

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