PUBLISHED

MAY 11, 1943.

BY A. P. C.

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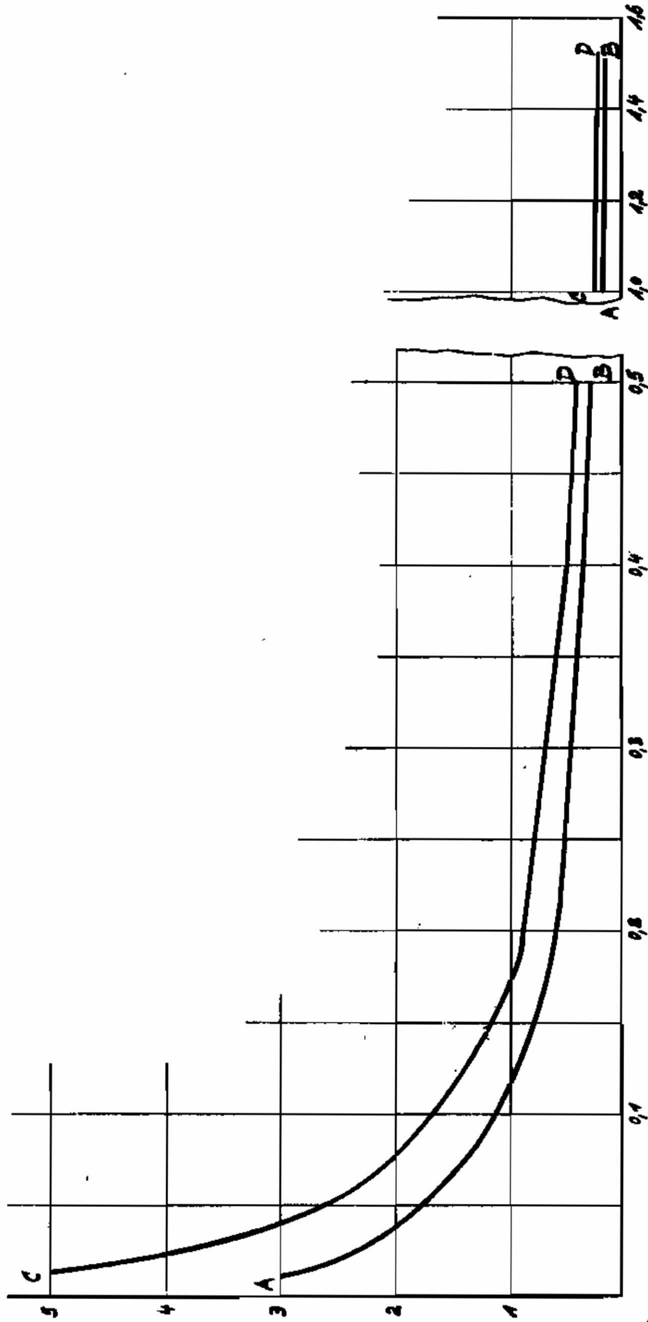
Filed June 6, 1940

Serial No. 339,132

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Published May 11, 1943 Serial No. 339,132

# ALIEN PROPERTY CUSTODIAN

## PROCESS FOR THE INTRODUCTION OF CHROMIUM INTO IRON OR STEEL ARTICLES

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Application filed June 6, 1940

This invention relates to improvements in or relating to a process for the introduction of chromium into iron or steel articles.

As it is known, the surface of iron and steel articles may be enriched in chromium by diffusion. This was done, according to previous methods, by packing the articles in chromium powder or ferrochrome powder and then heating the whole for many hours to very high temperatures, e. g. 1200 to 1300° C. Vaporisable chromium compounds are recently used for the introduction of chromium and especially vaporous chromium chlorine compounds, out of which chromium chloride has proved to be peculiarly suitable. By using vaporisable chromium chlorine compounds a considerable reduction of the high treating temperatures and of the treating period has been obtained, e. g. the treating temperature has been reduced to 1000° and the treating period to some 5 hours, in the course of which good chromium layers may be obtained on the surface to depths of 0.1 mm on an average.

The procedure of the chromium diffusion and the quality of the chromium layers formed on the surfaces also depend upon the composition of the materials to be treated, in so far as it is known that the chromium diffusion is rendered difficult with increasing carbon content of the same. For this reason, iron alloys having not more than 0.2%, possibly not more than 0.1%, have so far been demanded for the introduction of chromium.

However, experiments on a large scale have shown that a low-carbon prime material alone does not lead yet to a good progress of the introduction of chromium and to useful surfaces, because, as it has been found, such results do not depend upon the proportion of carbon but upon the total amount of the carbon in the material. It has been found that, when introducing the chromium, migration of the carbon from the interior of the cross section towards the surface takes place, and this migration is the stronger, the greater the carbon of the cross section. Thus, for instance, it is not possible, when the diffusion is carried out under the usual conditions, to produce satisfactory layers on an article made from steel of about 0.02% carbon content and having a wall size of about 10 mm, whereas very good and tough chromium zones are obtainable on the same steel and under the same conditions, if the article has a wall size of some 2 mm. This clearly demonstrates that, with respect to the diffusion process and the quality of the chromium layers formed on the surface, the wall size of the articles to be treated and the carbon content of the material to be treated depend upon each other and that there must be certain limits in this function, above which no useful chromium layers and below which very useful ones may be obtained. In view of the fact that it has been ascertained by previous experiments that the disadvantageous influence of the carbon may be suppressed by adding certain alloying elements to the iron, e. g. titanium, vanadium, niobium, manganese or aluminium, it is possible in each case—making use of the firm relation existing between the wall size and the carbon content of the articles to be treated—to produce with absolute certainty and in a most economic way useful chromiferous surfaces on iron or steel articles even higher carbon content and with an ample wall size tolerance.

The firm relation existing between the wall size and the carbon content with respect to the diffusion process and the quality of the chromium layers formed on the surface is, according to the invention, determined by the equation $a.b=F(b)$, in which equation $a$ is the wall size in millimetres and $b$ the percentage of the carbon content. If $F(b)$ exceeds a certain value in this equation, satisfactory chromium layers can no longer be produced on the surface of articles from pure iron-carbon alloys, i. e. there will result, when the diffusion is carried on under the usual conditions, chromiferous zones, which are brittle and have a relatively low resistance to corrosion. However, according to the present invention, this can be counteracted by adding to the alloys having such a value of $F(b)$ certain elements, which suppress the migration of the carbon in the cross section, e. g. titanium, manganese, niobium or aluminium.

The value of $F(b)$, above which the quality of the chromiferous surfaces is no longer satisfactory without additional alloying steps, and below which there will result in each case very good and useful chromiferous surfaces, may be substituted, in a manner which is absolutely sufficient for practise, for three roughly graduated ranks of carbon content by certain constants. For the lowest range of carbon up to about 0.05% C this constant is 0.08, for the range of about 0.1% to about 0.4% C this constant is 0.12, and for a range of 0.5 to about 1.5% C the constant is 0.17. These constants representing practical approximations only, they are subject to a variation of +0.02 max.

The drawing graphically illustrates in detail the reciprocity between the diffusion process and the quality of the chromium layer on the surface on the one hand and the wall size of the articles to be treated and the carbon content of the iron-carbon alloy from which they are made on the other hand.

In the diagram the curve AB indicates the limiting value of the product of the wall size and the carbon content of the articles to be treated, up to which value it is possible to produce by diffusion specially good chromiferous surfaces on non-alloyed iron or steel. The space between the curve AB and the co-ordinates encloses therefore the conditions which are to be observed in case of non-alloyed kinds of iron and steel in order to obtain chromium zones which can stand e. g. strong deformations like bending radius of about 2 mm. and which fully resist considerable wet corrosion. (Test in the salt water spray box.)

If it is intended to obtain the same properties of the chromiferous surfaces in case of wall sizes and carbon contents on the right hand of the curve AB, it is, according to the invention, no longer possible to use pure iron or steel for the production of the articles to be treated, but it is necessary to use iron-carbon alloys, which contain additions of titanium, vanadium, niobium or of elements of similar effect, and that at least up to such an amount that the total carbon content of the alloy is bound by them. The same effect can also be obtained by adding manganese or aluminium, e. g. in form of an alloy which contains, apart from about 0.1% carbon, about 3% manganese.

The transition of the properties of the chromiferous surfaces from the space on the left hand of the curve AB to the space on the right hand of the curve is not sudden, but between the curve AB and a further curve CD having a constant value for $F(b)$ which is by 0.06 higher, there is a space in which also non-alloyed kinds of iron and steel may still be coated by chromiferous layers which stand average deformations like light bending etc. and which resist humid air. This resistance is also indicated by non-corrosion in 30 percent hot nitric acid. If, therefore, it is intended to obtain chromiferous surfaces of this average quality only, the articles to be treated can be made of non-alloyed sorts of iron and steel and the carbon content of the same can be arranged with respect to the wall size of the articles so as to observe the conditions of the space between the curves AB and CD.

Whilst chromiferous surfaces of the good properties of the space on the left hand of the curve AB can be well obtained in the space on the right hand of the curve CD by completely binding the carbon content of the used alloys by means of titanium, vanadium, niobium or the like, chromium zones of the properties corresponding to those which are met in the space between the curves AB and CD can also be obtained on the right hand of the curve CD, by adding to the iron-carbon alloys from which the articles are made smaller quantities of titanium, vanadium, niobium or the like than it is necessary for completely binding the carbon content of the alloys.

To recapitulate the invention first discloses the knowledge that, with respect to the diffusion process and the quality of the chromium layers produced on the surfaces, the wall size and the carbon content of the articles to be treated depend on each other, and it further indicates those conditions which must be observed in order to obtain with certainty and highest economy those properties of the articles, into which the chromium has been introduced, which are demanded in each individual case. At the same time the method according to the invention is valid for each kind of the introduction of chromium by diffusion, i. e. for the diffusion in pure metallic condition as well as for the diffusion by means of vaporisable or vaporous chromium compounds, specially chromium chlorine compounds.

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