UNITED STATES PATENT OFFICE.

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CASE-HARDENING.

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To all whom it may concern:

Be it known that I, SAMUEL WHYTE, B. Sc., a subject of the King of Great Britain and Ireland, and residing at 41 Woodlands road, Redhill, in the county of Surrey, England, metallurgist, have invented certain new and useful Improvements Relating to Case-Hardening, of which the following is a specification.

This invention relates to a new method of producing casings on finished or partly finished articles of iron, steel, alloy steels, or the like.

The invention consists broadly in a new method of producing iron-carbon alloys or alloys of iron alloyed with other metals as a fused casing on the surface of finished or partly finished articles by heating them to a suitable temperature with borax in the presence of carbon preferably in the form of graphite.

The invention further consists in employing an alternating or direct electric current to facilitate the production of the case.

The invention also consists in employing a direct current and making the work the anode or the cathode according as rounded or sharp corners are desired.

In carrying the invention into effect in one form, a fused casing of white iron of suitable composition is formed by heating the iron or steel article in a bath of borax in a graphite crucible, or carbon is added, say in the form of a lining of graphite if a crucible not containing free carbon is used, and it is preferred to pass a current of air through the bath.

The depth and nature of the altered superficial layer or casing depends on the time of treatment and the temperature of the bath, as also of course upon the constitution of the original metal. The casing as it is formed is very fluid and tends to flow off. If after a slight uniform casing the article is placed in a cooler part of the bath or transferred to a bath of a lower temperature a diffusion of carbon would take place and give a deeper case. By controlling the temperature of the bath and the time of treatment in relation to the constitution of the original material, the depth and composition of the casing can be regulated. The temperature of the bath may conveniently be about 1200° to 1400° C. The presence of carbon insures fusion of the casing by maintaining its carbon content, as the carbon alloys of higher carbon content have lower melting points.

This process can be usefully applied in many ways. For example, an engine cylinder may be produced of steel, yet having a working surface of a white iron. Other applications of this invention are the casing of tubes or vessels, where the strength of steel is required with the corrosion or erosion resisting properties of white cast iron, or again the casing of turbine blades or fastening devices such as screws or nuts.

Where a thick coating is desired cast iron may be melted in the bottom of the crucible with a layer of borax or the like on the top, and articles may be coated rapidly with the required casing by dipping. The iron has its silicon rapidly eliminated by heating with the borax, and where sufficient carbon is used and time given the metal bath is readily converted into white iron of nearly constant carbon content containing about 2.7% of carbon; but the treatment may be stopped at an earlier point with a smaller carbon content if desired.

The articles to be coated become cleaned by the borax bath which is sufficiently deep for this purpose.

By dipping in the metal a coating of the desired depth can be obtained.

When desired metals which alloy with the iron carbon alloy may be introduced into the metal bath, *e. g.* copper, nickel, cobalt, tungsten, chromium, so that they will be introduced into the coating.

It will be seen that other arrangements may be made in relation to the shape and size of the article to be cased, the essential feature being the raising of the article to be treated to the reaction temperature in contact with the molten borax and in the presence of carbon.

In carrying this invention into effect in another form, an electric current is applied to the bath in the formation of the casing, preferably with the work as one electrode. In this way the casing is more rapidly produced.

When the article to be treated is made the anode, the casing produced has a high carbon content (probably iron carbid Fe_3C). It is correspondingly hard and microscopically is of single constituent. The corners of the article are rather more rapidly acted upon, and become rounded. If the article be made the cathode, a casing of lower car-

bon content is obtained (about eutectoid composition), and the original sharpness of the corners is not affected. An alternating current may be employed if desired.

Further one or both of the electrodes may be of carbon or of iron. Where an iron anode is used and the article is the other electrode, I find that the case has a duplex structure which appears to be the eutectic of white iron.

In one example I have coated a rectangular plate of steel of 500 sq. cms. surface with a case about 7/1000ths of an inch thick in 8 minutes, using the plate as the negative electrode, and employing a current of 50 amperes at 15 volts. Where the work is a negative electrode under the conditions I have worked, the limit of the carbon content of the casing appears to be about .9%, whereas if the work be the positive electrode then the limit appears to be the formation of the single constituent Fe_3C. This property may be employed conveniently to enable any desired carbon content to be obtained in the case.

In another example, therefore, I employed a similar plate to that above referred to, but coupled the plate for five minutes as the negative pole and for three minutes as the positive pole with the same current and voltage as before. The casing thus obtained was about 5/1000ths of an inch thick.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The method which consists in submitting articles of iron or steel to the action of a bath of molten borax in the presence of carbon and at such temperature of the bath and for such time of treatment that a casing of high carbon-iron (white iron) is formed on the article.

2. In a process according to claim 1, the application of an electric current to the bath with the article to be coated as an electrode.

3. In a process according to claim 1, the passing of a current of air through the bath.

4. An article of iron or steel having formed thereon a casing of white iron, the casing possessing the characteristics of a coating formed by submitting the articles of iron or steel to the action of molten borax in the presence of carbon.

In testimony whereof I have signed my name to this specification.

SAMUEL WHYTE.