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HARDENING OR TREATMENT OF STEEL, IRON, &c.

1,092,925. Specification of Letters Patent. Patented Apr. 14, 1914.

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To all whom it may concern:

Be it known that I, ADOLPH W. MACHLET, a citizen of the United States, residing in Elizabeth, in the county of Union and State of New Jersey, have invented certain new and useful Improvements in the Hardening or Treatment of Steel, Iron, &c., of which the following is a specification.

This invention relates to treating iron and steel articles, as well as articles of some other metals, in a manner to produce upon the articles a coating, skin, shell or finish, or to affect the nature of the articles throughout, as the case may be; that is, to harden and otherwise modify the articles, either exteriorly or throughout.

In the preferred manner of treating low-carbon steel articles according to my invention or discovery, they are placed in a retort such as shown in U. S. Letters Patent No. 822,460 of June 5, 1906, or No. 884,181, of April 7, 1908, or No. 961,305, of June 14, 1910, and the retort is heated to a carburizing heat, while a current of ammonia flows slowly through the retort, the ammonia having first been charged with naphtha, as set forth in said Patent No. 961,305. Or the ammonia may be in the form of bubbles taken up by hydrocarbon gas passing through the ammonia, as set forth in said Patent No. 884,181. By this means, the low-carbon steel is carburized as deeply as may be desired. This operation may continue from a few minutes to several hours, according to the depth of carburization desired, the quality of the material, etc. Then I shut off the naphtha, and cause the ammonia alone to flow slowly through the retort, for half an hour or more, while the said heat of the retort is maintained. If an ammonia-and-naphtha-mixing apparatus is used, a by-pass may be connected over from the ammonia supply to the retort-supplying pipe, said by-pass to be provided with a valve to close the same when desired. By this means, the ammonia may be made to flow either through the naphtha, as when carburizing the metal, or directly through the by-pass to the retort, without taking up any naphtha. One effect of the ammonia treatment is to rid the articles of any surplus deposit of carbon thereon. After a sufficient duration of the ammonia treatment subsequent to such carburization or case-hardening, I close the vent of the retort, and permit the retort to cool while the same remains filled with ammonia and contains the steel articles. This prevents access of air or oxygen to the articles; although the invention is not limited to this particular method of preventing oxidization of the heated articles. The articles when examined after cooling, are found to be not only case-hardened as set forth in said Letters Patent, but also to be provided with an integral skin, casing, shell or coating, which when unpolished has a silvery color, and is very compact and close-grained and hard, and is capable of taking a very high polish closely resembling polished silver. It is so hard that it is difficult to polish, and difficult or impossible to cut with an ordinary machinist's file; and in some cases it may be sufficiently hard to scratch glass. This coating is extremely reluctant to tarnish, corrode, or rust, or to oxidize; and under ordinary conditions may be regarded as practically proof against rust, as for instance in indoor use, or where it is not unduly exposed to the elements. Articles made according to my invention have been submitted to many tests at the same time with common steel untreated screws and other articles; and while the latter rusted in the expected manner, the former showed no signs of rust or even oxidization. The invention is therefore of value in treating parts of machines and instruments, to prevent their rusting, and give them an attractive finish, and avoid the necessity of nickeling, silvering or otherwise plating or finishing them; while the hardness of the casing renders it desirable for wearing parts, cutlery, and in numerous other arts. This silvery casing is much harder than iron or low-carbon steel. It is brittle, but owing to the qualities of the case-hardened shell which backs it up, and to the presence of the softer steel beneath said shell, the brittleness is found unobjectionable in practice. Said silvery casing is capable of being still further hardened by heating and quenching. It is magnetic. It is difficult or impossible to anneal said silvery casing by ordinary methods. It is not malleable when cold. It has a granular or granitic fracture of very fine grain. It may be acted upon by vitriol or muriatic acid in much the same manner as iron, but is very reluctant to yield to said acids. When red hot, said silvery casing is harder than tool steel at the same heat, and in many instances is too hard to be scratched with a file. If exposed to air when at a

red heat, it oxidizes more rapidly than tool steel or iron at the same heat. It will be understood that the articles may be carburized throughout, if desired, before being subjected to the final heating in pure ammonia, to form the coating. Substantially similar results may be obtained by similar treatment of Swedish iron or pure iron, or wrought iron, etc.

In treating gray cast iron, such as commonly employed for machine frames and small machine castings, and in which there is a relatively large amount of carbon as compared with low-carbon steel, I pass the ammonia through kerosene or heavy oil instead of through naphtha, so that the ammonia will take up only a little hydrocarbon on its passage into the heating retort; and I continue the heating of the cast iron five hours or more in the atmosphere of ammonia and hydrocarbon; finishing the treatment, however, with the half hour of the current of pure ammonia, and permitting the iron articles to cool in a bath of ammonia, as before explained. This produces upon the cast iron a hardened integral shell or casing, having substantially the same characteristics as already noted with regard to low-carbon steel articles treated according to my invention. If the cast iron, however, is first decarburized or made malleable, it may be treated in the same way as the low-carbon steel articles, with substantially the same results as before noted. With high-carbon or tool steel, the process should be substantially the same as with gray cast iron articles. The low-carbon steel articles, after carburization, may be subjected to the heat-and-ammonia treatment, as before, and then after cooling, they may be re-heated and quenched, and subsequently again heated and quenched; and this may be again repeated; each re-heating and quenching serving to improve the hardness and tenacity of the case-hardened or carburized portions of the articles. The re-heating in each instance should be done in a carbonaceous atmosphere. So far as the repeated re-heating and quenching is concerned, the ammonia finishing treatment may be omitted, as the re-heating and quenching improves articles case-hardened, even if they are not finished with the herein described coating. There should be no excess of carbon present in the retort.

By subjecting low-carbon steel to the heat treatment as aforesaid for several hours in an atmosphere of ammonia which has been passed through kerosene or heavy oil instead of naphtha (the ammonia, it will be understood, takes up less carbon or hydrocarbon from the kerosene than it does from naphtha), the entire mass of the steel becomes affected and brittle, and hardened, but not so hard as the skin or crust heretofore described. This metal is magnetic, and possesses many of the properties of said skin or shell. Now, if it is desired to form on this present metal a shell or crust such as hereinbefore described, it can be done in the hereinbefore described manner, viz., by subjecting the heated metal to the action of ammonia alone, for half an hour or more. The crust is exceedingly fine-grained and compact, in comparison with the body of the metallic article, besides being harder than said body. This coating or crust is only a few thousandths of an inch in thickness, and after repeated attempts I have been unable to make it much if any thicker; and I suppose that owing to the exceedingly compact nature of the crust, the ammonia (or ammonium or ammonium and carbon) in the retort is prevented from gaining access through the crust to the interior of said body, so that a crust of this character and of great thickness has not yet been formed, even after hours of exposure to the treatment. The crust, it has been seen, can be formed either on the body of the metal, or on case-hardened steel or iron, or directly on low-carbon steel or high-carbon steel or cast (gray) iron or on malleable iron or on wrought iron or on high-carbon steel—in fact on any metal of which iron is the main component.

Variations in the processes and metals may be resorted to within the scope of the invention. In carburizing previous to incrusting the metal, a gas consisting only of hydrogen and carbon may be employed to flow through the retort; that is to say, the nitrogen component of ammonia may be omitted when case-hardening articles, whether or not they are to be subsequently incrusted with the new hard silvery metal herein described.

Not only metals of the iron class, but also other metals, as for instance nickel, may be subjected to the herein described treatment to incrust the same in like manner; and it will be understood that in many cases, as for instance in incrusting small articles in bulk, it is preferable to rotate the retort during the operation of heating the articles in an atmosphere of the described gases, so as to agitate the articles and expose them all over to the action of the gas, and cause every side of each article to come uppermost in turn. I also recommend, instead of passing ammonia through carbon, to use pure ammonia to which a plenum of hydrogen has been added (NH_3 plus H); this gas to be used for either affecting the body of the article, or simply for incrusting the same with the hard substance described.

Having thus described my invention, I claim:

1. The process of treating iron or steel, comprising the steps of heating the metal at

least to about red heat in an atmosphere of ammonia and hydro-carbon, and then in an atmosphere of ammonia.

2. The process of treating iron or steel articles, comprising the steps of heating them at least to about redness in an atmosphere of ammonia which has been passed or filtered through kerosene, and then in an atmosphere of ammonia alone.

3. The process of passing ammonia through a heavy oil and introducing it into a heated retort containing iron or steel articles, and then causing a current of ammonia alone to flow through the retort over the heated articles.

4. The process of treating low-carbon steel or iron comprising the steps of heating it in an atmosphere of ammonia which has been passed through kerosene, until the article throughout is converted into a hard, brittle, silvery substance and then continuing the action with ammonia alone.

5. The process of carburizing iron or steel articles, and then exposing them to ammonia to rid the articles of the surplus deposit of pure carbon upon their surfaces, while the articles are still red hot or above red heat from the carburizing operation, and then cooling them without access of air or oxygen.

6. The process of treating iron or steel, comprising the steps of heating the metal to or about red heat in an atmosphere of ammonia and hydro-carbon, and then in an atmosphere of ammonia, then permitting the articles to cool, then reheating and quenching the articles, and then again heating and quenching them.

7. The process of treating iron or steel comprising the steps of heating the metal to or about red heat in an atmosphere of ammonia and hydro-carbon, and then in an atmosphere of ammonia, then permitting the articles to cool, then reheating the articles in a carbonaceous atmosphere and quenching them, and then again heating and quenching them.

8. The process of passing ammonia through kerosene and introducing it in a heated retort containing metal articles, to cause the latter to combine with the constituents of the ammonia and kerosene, and then introducing ammonia alone into the retort while the articles are still heated.

9. The process of passing ammonia through kerosene and introducing it in a heated retort containing metal articles to cause the latter to combine with the constituents of the ammonia and kerosene, then introducing ammonia alone into the retort while the articles are still heated, and permitting the articles to cool without exposure to air.

10. The process of treating iron or steel articles by exposing them when heated to an atmosphere of carburizing gas and ammonia to produce a shell or coat thereon, and then exposing them while still heated to an atmosphere of ammonia alone, and then permitting the articles to cool in an atmosphere devoid of oxygen.

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