UNITED STATES PATENT OFFICE.

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ART OF HARDENING AND TOUGHENING METALS.

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To all whom it may concern:

Be it known that I, JAMES CHURCHWARD, a subject of the King of Great Britain, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in the Art of Hardening and Toughening Metals, of which the following is a specification.

This invention relates to a process for making castings of iron and steel hard and tough, and while applicable to castings for any use or purpose the process is especially applicable to the production of armor-plates and the like.

In explaining the carrying out of the invention it will suffice to describe the actual process which is preferably employed in making a hardened and toughened steel plate—such, for example, as an armor-plate suitable for a war-ship, although the procedure may be slightly varied, as well as the proportions of the ingredients employed when dealing with castings for this and for other uses.

For making an exceptionally hard and tough armor-plate the following ingredients and proportions may be employed: carbon steel, (pure, with 0.20 carbon,) 81.5; nickel, 10.0; chromium, 5.0; manganese, 2.0; tungsten, 1.0; vanadium, 0.5; total, 100.0.

The carbon steel used should be practically pure with about 0.20 of carbon. The nickel and chromium used should be the pure metal. The tungsten, manganese, and vanadium used may be in the forms of ferro-tungsten, ferro-manganese, and ferro-vanadium; but the best results will be attained with the pure metals. A larger percentage of manganese than that given above may be used without disadvantage; but such a large percentage will not ordinarily be required.

The steel and alloying metals may be melted together up to 2,500° Fahrenheit; but care must be taken not to exceed 2,600° Fahrenheit if possible; or the nickel, chromium, and manganese may be melted together separately from the steel and brought to a temperature of 2,500° Fahrenheit and the tungsten and vanadium then added. This molten mixture of the alloying metals will be added to the molten steel. A small percentage of the chromium will be lost in the melting; but this is provided for in the proportion of this metal given above.

Great care should be taken to prevent the temperature of the molten steel alloy from rising above 2,600° Fahrenheit, and when it is molten and ready it should be at once poured into the mold.

The mold should be of metal strong enough to hold the metal casting in place, and it should be lined where it comes in contact with the casting with a plaster composed of the black oxid of manganese mixed with any suitable medium, as water, molasses, &c., and allowed to dry. It may be explained that this lining of the mold with manganese dioxid is in order to surround the casting with a substance that will not add silicon or carbon to the casting. The absorption of carbon or silicon from the mold would in many cases injuriously modify the alloy of the casting if brought into contact with the same.

When the casting shall have been in the mold long enough for it to set or harden sufficiently to be handled, it is taken out. The sooner it is taken out the better, and the more rapidly it can be cooled to the point where it can be safely removed the better. After being removed from the mold it is taken at once to the press to be pressed. Its temperature at this time should be about 2,100° Fahrenheit or a little less or otherwise it may have to be reheated. It is preferable to press the casting without reheating, as the grain will then be finer and harder. In the press it should be reduced to about one-third of its original thickness. Pressing plates in this manner is not in itself new, and obviously the plate may be compacted by other equivalent and known means, as rolling or forging.

The plate after pressing is placed to cool in a bath composed of a phenol and some fatty substance. Preferably, for the purpose of treating the plate produced as described above, the bath may be composed of carbolic acid, thirty parts; linseed-oil, seventy parts; total, one hundred. This bath should be kept as cool as possible, and this may be effected with a jacket of running water or one of ice. The object is to cool the plate quickly, and it should remain in the bath until perfectly cool. The plate should have a temperature as near 1,800° Fahrenheit as possible when submerged, and it should not be removed until cold.

The proportion of liquid in the bath to the weight of the plate or casting treated is not deemed very important. The casting must be submerged, and it is preferred that the proportion in volume of the liquid to the metal

shall be about seven to one. A portion of the oil goes off in vapor and a trace only of the carbon goes into the plate. One submersion of the plate is sufficient, provided it is hot enough when it enters the bath, and this temperature should not be lower than 1,200° Fahrenheit and may be as high as 2,000° Fahrenheit.

The proportion of the ingredients of the bath should be maintained by adding one or the other from time to time to make up for what has been lost.

To increase the ductility of the plate, the percentage of carbon should be reduced. Vanadium adds toughness to the alloy without in any way affecting its hardness produced by the other alloying ingredients. The resultant alloy when polished resists oxidation or rust to a remarkable degree.

In the bath linseed-oil may be substituted by other oils or fatty substances or glycerin, (glycerol,) and the word "fatty substance" is intended herein to include glycerin.

For carbolic acid (phenyl hydroxid) any phenol or suitable phenol derivative may be employed with good results, as creosote, (a monohydric phenol), for example. The word "phenol" as herein used is intended to include any one or all of these substances. The phenol if used pure causes such a sudden shock that the shrinkage and tightening of the outer skin of the metal causes the steel to crack. Therefore an oil or some fatty substance is mixed with the phenol to modify the effect. The oil or fat prevents the metal from cooling suddenly, so that the pores of the metal remain open for a very short period of time. During this period the phenol penetrates and acts on the inner metal, thereby carrying the depths of hardening to any degree required. Temperatures govern the action a great deal. A high temperature or a series of high temperatures will carry the hardening to the center of the metal; a low temperature will only carry in a short distance.

By the word "manganese" as herein used is meant the metal manganese or any of its compounds or mixtures which will yield manganese by reduction in the process described.

This invention is not limited to carbon steel as a basic metal or stock for the alloy. If crucibles are used, pure iron may be used as stock; but pure carbon steel is best, and it provides the cheapest way of getting an even distribution of the carbon throughout the alloy.

Obviously the pressing of the casting may be omitted in some cases; but this is an important step in the preparation of hardened plates.

Having thus described my invention, I claim—

1. The herein-described improvement in the art of hardening and toughening iron and steel, which consists in forming an alloy of the metal with small quantities of nickel, chromium, manganese, tungsten and vanadium, then casting the same in a mold, and then immersing the hot casting in a bath containing a phenol and allowing it to cool therein.

2. The herein-described improvement in the art of hardening and toughening steel, which consists in melting together steel, nickel, chromium, manganese, tungsten and vanadium, casting the molten metal in a mold in contact with a surface containing manganese, then pressing the casting, and finally immersing it until cold in a cold bath consisting of a fatty substance and a phenol.

3. The herein-described improvement in the art of hardening and toughening steel and iron, which consists in fusing an alloy of carbon steel, nickel, chromium, manganese, tungsten and vanadium, then casting the alloy in contact with a surface containing manganese, and then, while still at a suitable temperature, submitting the casting to pressure, and finally immersing the pressed casting, while at a suitable temperature, in a cold bath consisting of carbolic acid and a fatty substance and allowing it to remain so immersed until cold.

In witness whereof I have hereunto signed my name, this 5th day of December, 1905, in the presence of two subscribing witnesses.

JAMES CHURCHWARD.

Witnesses:
HENRY CONNETT,
H. G. HOSE.