UNITED STATES PATENT OFFICE.

ROBERT A. HADFIELD, OF SHEFFIELD, ENGLAND.

PROCESS OF HARDENING STEEL.

No. 810,531. Specification of Letters Patent. Patented Jan. 23, 1906.

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To all whom it may concern:

Be it known that I, ROBERT A. HADFIELD, a subject of the King of Great Britain, residing at Sheffield, county of York, England, have invented an Improvement in Processes of Hardening Steel, of which the following is a specification.

In the resistance to compression offered by a number of different kinds of hard steel I have found by experiment that there are comparatively small differences up to a certain load per square inch; but this difference changes greatly when the compression is further increased.

This invention has for its object the production of a method or process of treatment for steel whereby the resistance thereof to compression when subjected to considerable pressure is very greatly increased.

The steel to be treated, whether in cast or forged form, is heated, either directly or after being annealed, in any desired manner to a temperature of not less than about 850° centigrade, and it may be up to from 1,000° centigrade to 1,150° centigrade, depending upon the amount of carbon in the steel and the degree of hardness or stiffness it is desired to impart thereto. For hard steel containing, say, about 0.8 per cent. carbon the steel is heated to a temperature of not less than 850° centigrade and it may be upward to a temperature of from 975° centigrade to 1,000° centigrade, the harder the steel required the higher the temperature to which it is heated, the heating being conducted in any suitable furnace. The heated steel is then allowed to cool down either completely to about the temperature of the external air or only partially—say to about 300° centigrade to 400° centigrade. The cooling may be effected in the heating-furnace, but preferably in the open air, whether the cooling be complete or only partial, and if it is desired to secure greater toughness in the resultant product complete cooling may be conducted in sand or other suitable non-conducting material. After the preliminary heating hereinbefore described and the subsequent cooling the steel is reheated to a temperature of from about 500° centigrade up to about 720° centigrade and then allowed to cool. The harder the steel is required the lower should be the reheating temperature, and the tougher the steel is required the higher should be the reheating temperature. For example, to obtain a harder steel the reheating may be carried to about 600° centigrade, whereas if a tougher steel is required the reheating may be carried up to about 680° centigrade. I have found, however, that a temperature of about 720° centigrade should not be exceeded, as in such case the steel will become too soft and lose its stiffness or resistance to high compression stress. In the reheating, therefore, temperatures above 720° centigrade should be avoided. When only a partial cooling of the steel is effected after the preliminary heating, either in the furnace or the open air, the latter being preferred, the steel is reheated after its temperature is lowered to from 300° centigrade to 400° centigrade. The final cooling after reheating may be effected in any convenient manner—as, for instance, in one or other of the ways hereinbefore mentioned for the cooling after preliminary heating.

By the process described steel can be obtained whose resistance to compression is as high, if not higher, than that of water-hardened steel, but which is less brittle, so that by the process described it is possible to obtain without incurring the stresses set up by water-quenching a steel of great hardness and of greater strength than water-hardened steel. The difficulty of water-quenching steel is intensified by the fact that it is not practicable to quench beyond a certain temperature, as steel is liable to crack in hardening when heated beyond from 780° to 850° centigrade, according to the size of the article, whereas in conformity with my present invention there is no sudden cooling, and the steel can be heated to the high temperatures referred to without damage.

My invention is applicable to steel of various grades, the stiffening temperatures being higher the lower the percentage of carbon.

The softness hereinbefore referred to in various steels is probably due to the carbon present in the steel being in the form known as "carbid carbon" and the steel while very tough is comparatively weak in its resistance to high compression stresses.

By treatment of the steel as hereinbefore described the carbon is transformed or changed again into the hardening form to a greater or less degree, according to the heating temperature employed. The higher such temperature the higher will be the amount of hardening-carbon present and the harder will be

the steel, and its resistance to compression stresses is thereby increased. In treating steel containing about 0.8 per cent. carbon, referred to herein, the minimum is about 850° centigrade and the maximum desirable temperature is about 1,000° centigrade, while for a softer steel the minimum temperature should be increased, say, to about 900° centigrade and the maximum to from about 1,075° centigrade to 1,100° centigrade.

My invention is particularly adapted to the treatment of hard steel for use in the manufacture of armor-piercing projectiles to stiffen them and increase their strength and resistance to compression; but my invention is also applicable to the treatment of steel used for a variety of other purposes, such as shoes and dies for ore-crushing apparatus, the wearing parts of crushing machinery, rolls of various kinds, car-wheels, and cutting-tools of various kinds.

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

1. The method of hardening steel which consists in raising the temperature of the steel to about 975° centigrade; permitting it to cool slowly; reheating the cooled steel to a temperature of about 500° centigrade; and permitting the steel to cool slowly after such reheating.

2. The method of hardening steel and imparting thereto high resistance to compression, which consists in raising the temperature of the steel to above 850° centigrade and not over 1,150° centigrade; permitting it to cool slowly; reheating the cooled steel to a temperature of or over 680° centigrade, and permitting the steel to cool slowly immediately after such reheating.

3. The method of hardening steel and imparting thereto high resistance to compression, which consists in raising the temperature of the steel to between 975° centigrade and 1,000° centigrade; permitting the steel to cool slowly; reheating the cooled steel to a temperature of or over 500° centigrade, and slowly cooling the steel after such reheating.

4. The method of hardening steel, which consists in raising the temperature of the steel to above 850° centigrade and not over 1,150° centigrade; permitting it to cool slowly to about the temperature of the external air; reheating the cooled steel to a temperature not higher than 720° centigrade, and finally slowly cooling the steel after reheating.

5. The method of hardening steel, which consists in raising the temperature of the steel to not less than 850° centigrade and not more than 1,150° centigrade; permitting the steel to cool; reheating the cooled steel to a temperature not higher than 720° centigrade, and immediately thereafter permitting the steel to cool slowly from the reheating temperature.

6. The method of hardening steel which consists in raising the temperature of the steel above 975° centigrade, and below 1,150° centigrade, permitting it to cool slowly; reheating the cooled steel to a temperature of or over 500° centigrade, and finally slowly cooling the steel after such reheating.

7. The method of hardening steel and imparting thereto high resistance to compression, which consists in raising the temperature of the steel to about 975° centigrade, permitting the steel to cool slowly, reheating the cooled steel to a temperature of or over 680° centigrade and below 720° centigrade, and slowly cooling the steel from such last-named temperature.

8. The method of hardening steel, which consists in raising the temperature of the steel from about 850° centigrade upward, and not higher than 1,150° centigrade; cooling the steel to not more than 400° centigrade; reheating the partially-cooled steel to about 500° centigrade and upward, and finally permitting the reheated steel to cool.

9. The method of hardening steel which consists in raising the temperature of the steel to from about 850° centigrade upward to but not higher than 1,150° centigrade, according to the amount of carbon in the steel; cooling the steel slowly to not more than 400° centigrade, reheating the cooled steel to a temperature of about 500° centigrade and upward according to the hardness or toughness required; and immediately and slowly cooling the reheated steel from the reheating temperature.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ROBERT A. HADFIELD.

Witnesses:
BAIN L. CAMPBELL,
LUTHER J. PARR.