No. 754,301. Patented March 8, 1904.

UNITED STATES PATENT OFFICE.

ROBERT A. HADFIELD, OF SHEFFIELD, ENGLAND.

MANUFACTURE OF HARDENED-STEEL PROJECTILES OR OTHER ARTICLES.

SPECIFICATION forming part of Letters Patent No. 754,301, dated March 8, 1904.

Application filed June 24, 1901. Serial No. 65,802. (No model.)

To all whom it may concern:

Be it known that I, ROBERT A. HADFIELD, a subject of the King of Great Britain, and a resident of Sheffield, county of York, England, have invented an Improvement in Manufacture of Hardened-Steel Projectiles or other Articles, of which the following is a description.

In the manufacture of hardened-steel projectiles or other articles carbon or other steel has been heated to a certain temperature, commonly about 750° centigrade, and then quenched in cooling-baths of water or oil in order to obtain what is technically known as "glass-scratching hardness." This process necessitates exceedingly careful treatment of the steel to avoid water-cracking, and in the case of projectiles, even when the water-quenching has been most carefully performed and apart from the liability to cracking during or immediately after the hardening process, there has been a tendency to weaken the article treated, owing to internal tension.

So-called "self-hardened" steel has been produced in the forged form, but for projectiles and a variety of other articles it has been too brittle.

My present invention has for its object a method of treatment whereby the foregoing objectionable features are successfully overcome.

In accordance with my invention articles made of suitable steel—that is to say, nickel-chromium-steel, cast or forged—are hardened by heating to a temperature considerably higher—say 200° or thereabout—than has been employed heretofore for such hardening in the ordinary manner, and the heated articles are thereafter cooled by direct exposure to the action of air in the form of a blast or current or a plurality of blasts or currents, which may be at a very low temperature—that is, much below the temperature of atmospheric air—in a manner to effect the cooling with the rapidity necessary to produce the desired degree of hardness.

In practicing my invention self-hardening effects may be obtained, though, of course, in a much slighter degree than at the higher temperature, at, say, 150° higher than the water-hardening temperature.

The temperature to which the article is to be heated will to some extent depend upon the degree of hardness required, and the temperature will vary according to the size of the article to be treated. By this I mean that higher temperatures must be employed for large articles than is necessary for smaller ones. Take wire, for instance, and compare it with a four-inch or six-inch projectile. If the wire is subjected to a temperature high enough to effect the desired hardening and the projectile is subjected to the same temperature, there will be practically no hardening effect whatever on the projectile, because of its greater size and the fact that by its very size a greater temperature must be employed to attain the same hardening which is effected in the wire. So, too, a thin plate and a thick one must be subjected to different temperatures in order to secure the same hardening effect in each.

If a specially hard product be required, the temperature and the rapidity of cooling may both be increased.

Where comparative toughness is required, the necessary hardening temperature will be lower than that hereinbefore mentioned and the rate of cooling will depend to some extent upon the composition of the steel to be hardened.

My process can be employed for hardening the interior surfaces of hollow articles—such, for example, as projectiles—by directing the cooling air blast or current upon the internal surface which is to be hardened.

Hardened-steel articles can be advantageously produced by using in the manufacture of such articles steel such as is described in my British Patent No. 27,753 of 1897 and effecting the hardening by heating to a high temperature and subsequently effecting air-cooling in accordance with my present invention.

Cast projectiles produced as in the patent referred to can be annealed in the ordinary manner, then heated in a suitable furnace to a temperature of, say, from about 900° centigrade (internally) upward, then removed from the heating-furnace and subjected to an air blast or current, as hereinbefore set forth.

The temperature of the heating to which the article is subjected will depend upon the character of the steel. Thus I find that manga-

nese has a powerful effect in promoting the hardening of nickel-chromium steel and that while the presence of manganese in, for example, projectiles made of such steel would prevent their being hardened in the ordinary way because of their liability to break in the process, yet by heating to a higher temperature than would be safe for water-hardening and then cooling them by the impact of a blast of air such articles become exceedingly hard and satisfactory as regards quality.

Very satisfactory results can be obtained with a steel containing, say, C 0.80, Si 0.20, S 0.04, P 0.04, Mn 0.12, Ni two, and Cr two per cent.; but this is only mentioned as one example, and it is to be understood that in practicing my invention I do not restrict myself to this particular composition nor to the proportions hereinbefore stated.

In some cases it may be found desirable to treat by my novel process steel containing nickel, chromium, and tungsten. The presence of chromium and nickel result in great toughness in the finished article.

I consider it will usually be desirable that chromium shall be present, and nickel also, where great toughness is required, manganese being added when still greater hardness is required.

While the addition of manganese to the steel to be treated intensifies the hardening effect, it adds brittleness to the articles.

In the case of a projectile by varying the temperature to which the portion intended to be hardened is heated so is the hardness varied.

While my present invention is very beneficial in the manufacture of projectiles, it can be used with great advantage and highly satisfactory results in the production of other hardened-steel articles of various kinds, (especially castings,) including, *inter alia*, shoes and dies for ore-crushing, the wearing parts of crushing machinery, rolls of various kinds, car-wheels, railway-wheels, cutting-tools of various kinds, and articles with hard steel as a facing and a soft backing—that is, combined pieces—the hard portion or face thereof being hardened by my process.

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

1. The method of hardening nickel-chromium-steel articles, which consists in heat-treating the article to raise the temperature thereof to about 900° centigrade and upward, and thereafter subjecting such heated article to the direct action of a blast or current of air.

2. The method of hardening nickel-chromium-steel projectiles, which consists in heat-treating the projectile to raise the temperature thereof to about 900° centigrade and upward, and thereafter subjecting such heated projectile to the direct action of air at low temperature.

3. The method of producing hardened-steel articles, which consists in casting the article of nickel-chromium steel, raising the internal temperature of the article to 900° centigrade and upward, and thereafter subjecting the heated article to the action of a blast or current of air.

4. The method of producing hardened-steel projectiles, which consists in casting the projectile of nickel-chromium steel, raising the internal temperature of the projectile to 900° centigrade and upward, and thereafter subjecting the heated projectile to the action of a blast or current of air.

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

ROBERT A. HADFIELD.

Witnesses:
A. C. LEVIS,
LUTHER J. PARR.