# UNITED STATES PATENT OFFICE.

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## MANUFACTURE OF STEEL.

SPECIFICATION forming part of Letters Patent No. 559,359, dated May 5, 1896.

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*To all whom it may concern:*

Be it known that I, JAMES HENRY CARPENTER, a citizen of the United States, residing at Reading, in the county of Berks and State of Pennsylvania, have invented certain new and useful Improvements in the Manufacture of Steel, of which the following is a specification.

My invention relates to the manufacture of steel, and has for its object to improve the processes of manufacturing steel, and more especially what is generally known as "self or air hardening steel."

To these ends my invention consists in the process of making air-hardening steel, and in such steel having the characteristics substantially as hereinafter more particularly described.

The general characteristics of air or self hardening steel are well known and need not be specifically recited, and it is the object of my invention to not only improve or increase the general good qualities of this material, but to add thereto and to produce a steel which shall overcome the well-known defects existing in a steel of this general character as heretofore made.

In carrying out my invention I use a composition of refined bar-iron, pig-iron, cast-steel, or ores combining two or more of these materials in the composition in varying proportions, according to the results to be obtained. These materials are mixed or combined with the various ingredients substantially as more particularly pointed out hereinafter, and the metal may be melted in crucibles or treated in steel-making furnaces, and may be manipulated in the usual and ordinary ways of manufacturing steel.

In treating the metal, as above intimated, I make use of the various materials, depending principally upon the purposes for which the steel is intended, and depending to a greater or less extent upon the character of the iron or steel treated. Thus, for instance, when refined bar-iron is used I combine with it a certain proportion of chromium, a certain proportion of manganese, and a certain proportion of rutile. In all instances in treating refined bar-iron I use the chromium and manganese with rutile.

I use the word "rutile" to denote the rutile of commerce, which is a titaniferous iron ore containing titanic oxid.

In order to more clearly define my invention, I will give some of the relative proportions in which I have found it useful to combine these materials with refined bar-iron. Thus in some instances I make use of four per cent. of chromium, one per cent. of manganese, and one per cent. of rutile. In other cases I have found that three per cent. of chromium, one per cent. of manganese, and two per cent. of rutile produce desirable results. In other instances I have found two per cent. of chromium, one per cent. of manganese, and three per cent. of rutile. This latter composition produces a steel having the characteristics of hardness to a greater degree than the other proportions, while when the chromium is used in larger proportions the steel has the characteristic of toughness to a greater degree, while the other materials produce the requisite hardness and other qualities of the steel. Thus it will be seen that by varying the relative proportions of the chromium and rutile I am enabled to produce a product having the distinguishing characteristic desired to a greater or less degree.

When I use cast-iron or cast-steel in producing my improved product, I have found it advantageous to combine with the materials above referred to a certain proportion of nickel, as this tends to overcome the brittleness inherent in ordinary cast-iron, giving to it the general properties or characteristics of wrought-iron. Thus, as an example, in using cast-iron I combine therewith two per cent. of chromium, one per cent. of manganese, two per cent. of rutile, and from two to three per cent. of nickel. In other instances I can use one per cent. of chromium, one per cent. of manganese, two per cent. of rutile, and from two to three per cent. of nickel, the exact percentage of the materials used in any composition being regulated according to the toughness or hardness of the steel to be produced. In using these various materials in combination with the wrought-iron and cast-iron, while it may be difficult to explain fully the exact action of each material on the metal it may be said in general that the addition of the chromium tends to toughen the product

and to assist in hardening, while the manganese adds to the ductility of the product and performs the usual functions of acting as a cement. The rutile tends to produce hardness and toughness in the product, and the nickel when added to the cast-iron, as before intimated, tends to overcome the inherent brittleness of the cast-iron and produces the qualities of wrought-iron. By combining these various materials in proper proportions and in substantially the proportions above indicated I am enabled to give to the product the general characteristics set forth in the highest degree and produce a steel which is superior to all others heretofore known.

I have found that steel thus made is suitable for castings and forgings, has a high degree of ductility and increased physical conditions—such as tensile strength, elongation, &c.—standing tests of this character to an exceedingly high degree. It is capable of hardening in air whether applied by pressure or otherwise, and it can be hardened to a greater depth than other steels. The metal is also capable of being forged, rolled, or machined and is suitable for plates, bars, rods, blocks, and shapes which may be used for machinery. It is especially applicable to the manufacture of tools, knives, drills, reamers, and the like, and I have found that tools made from this material have greater endurance with increased speed and depth of cutting than anything heretofore known and this without heating or losing its hardening or tempering qualities. These and other qualities render the material exceedingly valuable for use in projectiles, especially for the purpose of piercing and destroying armor-plates and protective forgings, as on war vessels and batteries, its hardening qualities and toughness enabling a projectile made from this material to penetrate deeper and with more destructive effect the hardest and strongest armor-plates known. Moreover this steel having these general qualities produces a great saving over the ordinary methods and means practiced in attempting to attain these general results, as it hardens quickly and without loss of material in air, and it may be hardened in cooling liquids when other steels will fail and crack and become otherwise injured. It is evident also that these general characteristics make the steel a desirable material for use as a protection for safes and other articles where it is desired to resist the action of drills and other cutting-tools and the effects of concussions or blows.

I am aware that heretofore chromium has been combined with wrought-iron in making steel, but it has been combined in comparatively large quantities and with steel having a high percentage of carbon, and while it produces beneficial results it does not produce a steel which is practically forgeable under ordinary conditions.

I am also aware that steel has been made in which there was a comparatively large proportion of carbon, and which has been combined with manganese, wolfram, and silicon; but this composition does not produce a steel having the qualities of forging under ordinary conditions and it is not as tough as the steel produced in the manner above set forth, nor has this steel the quality of hardening in water without injury or loss.

I am also aware that it has been proposed to make steel by combining with the iron or steel manganese and wolfram or tungstic acid. The wolfram in this combination renders the steel exceedingly hard and brittle, so that it is incapable of forging, while the addition of rutile or titaniferous iron ore in connection with other materials has the tendency of softening the steel and toughening it and is especially useful in the so-called "air-hardening" steel, it apparently tending to retard the hardening and adding to the toughness, even when the steel is high in carbon.

What I claim is—

1. In the process of making air-hardening steel, adding to the molten iron two to four per cent. of chromium, one per cent. of manganese and one to three per cent. of rutile, substantially as set forth.

2. In the process of making air-hardening steel, adding to the molten cast-iron one to two per cent. of chromium, one per cent. of manganese, two to three per cent. of rutile, and two to three per cent. of nickel, substantially as set forth.

3. Air-hardening steel, composed of iron two to four per cent. of chromium, one per cent. of manganese, and one to three per cent. of rutile, substantially as set forth.

4. Air-hardening steel, composed of cast iron or steel one to two per cent. of chromium, one per cent. of manganese, two to three per cent. of rutile, and two to three per cent. of nickel, substantially as set forth.

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

JAMES HENRY CARPENTER.

Witnesses:

F. L. FREEMAN,

ALLE N. DOBSON.