UNITED STATES PATENT OFFICE.

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HEAT TREATMENT OF MANGANESE STEEL.

1,017,907. Specification of Letters Patent. **Patented Feb. 20, 1912.**

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To all whom it may concern:

Be it known that I, Winfield S. Potter, a citizen of the United States, residing in the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Heat Treatment of Manganese Steel; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In Letters Patent of the United States granted to me under date of November 8th, 1910, No. 975,371, I have described the production of shapes for manganese steel which has first been brought to a uniform austenite or gamma-iron state by heating to temperatures above 1125° C. and has then been worked to the form contemplated, which may be either the final finished articles, such as a rail or the like, or an intermediate shape such as a bloom, billet, slab, or bar. At the termination of the working operation, in some of these instances, it may happen, because of the exigencies of the mill, or from some other cause, that the worked product may require reheating in order to bring it to its ultimate condition, or its ultimate shape and condition. As a consequence, the product as it leaves the rolls or other forming mechanism may, in these instances, be regarded as a preliminary product, which has had the advantage of the heat treatment and working described in my patent referred to, but which will require further treatment in its progress toward the ultimate product or products desired. For instance, where the preliminary product is a bloom or billet, and where it is not feasible to immediately proceed with the rolling of a rail or the like therefrom, a reheating operation, either from the cold state, or from a temperature intermediate between the heat of rolling and the cold state is essential for the final forming operation. So also, where the preliminary product is a slab, with more or less divergence in temperature conditions throughout its mass, which would interfere with its further forming into final products, reheating is likewise frequently desirable; and, finally, when the preliminary product is a bar or other commercial shape, or even a rail or the like which may issue from the forming rolls at a temperature too low to insure the desired toughness by quenching, a reheating operation is desirable.

In the treatment contemplated by my United States Letters Patent No. 975,371, hereinbefore referred to, the ingot, having first been brought to the uniform austenite condition, changes in structure, during the rolling to a bloom or other shape, by the breaking down of the austenite grains. The size of the resulting broken grains depends upon the percentage of total reduction effected by the rolls, the amount of reduction in each pass, (that is, the deepness and suddenness of the reduction), and also on the finishing temperature. For example, if in rolling a rail it is finished with considerable variations in its temperatures, the grains in the central portion of the head of the finished rail will be many times larger than the grains in the edge of the base of the rail, for the reason that the pressure is greater and the reduction more severe in producing the edge of the base than in forming the head, and also because the larger section of the head, retaining the heat, is finished at a higher temperature than the edge of the base. The grains are irregular in form, and have not the uniformity of outline characteristic of the grains in steel which has been heated to 1200° C. for example, and cooled rapidly without mechanical work.

When the bloom or other shape leaves the final pass of the rolls at a temperature materially above 950° C. or thereabout, and if the metal is then permitted to cool slowly, changes begin to make themselves manifest in an important degree according as the finishing temperature is higher, and increase in magnitude as the cooling is slower. The first change consists in a separation of the carbids along the needles or fibers of the austenite structure within the grain. In manganese steels, containing for example, 1.20% carbon this causes a change in the grain structure from austenite to martensite. Carbid separations also occur between the grains of the metal, and, if the metal is now cooled either rapidly or slowly to atmospheric temperature, it is weak and brittle. For example if the steel is slowly cooled from say 1125° C. to 950° C. and is then cooled either slowly or rapidly, it is brittle when cold. Or the metal is brittle when cold if slowly cooled from above 950° C. to 720° C. Very slow cooling through the range from

720° C. to about 640° C. brings about a further separation between the different carbids present and a still weaker condition in the cold state. Similarly, slow reheating through the range from about 640° C. to 720° C., and slow reheating from say 950° C. to 1125° C., followed by either slow or rapid cooling, produces a weak and easily cracked or ruptured state of the steel. While in such condition, the manganese steel should not be rapidly heated or rapidly cooled, as a considerable and general cracking, followed by internal oxidation, may, in this way, occur.

I have found that by carefully reheating the steel to between about 975° C. and about 1075° C. for a very short time, the separations occurring at temperatures below 950° C. are restored to solution, and that by carefully heating to above 1125° C. the separations occurring above 950° C. during slow cooling or slow reheating are also restored to solution. However, the steel reheated to above 1125° C. has a coarse, though uniform austenite structure, and, although in a suitable condition for further rolling or other working, has not a satisfactory stiffness or strength even though it were now quenched from the temperature above 1125° C. The steel in this coarsely regrained austenite state may be given a finer grained and strong austenite structure by cooling down and reheating without any long rest at any temperature between about 640° C. and about 775° C. or between about 950° C. and any higher temperature (for example, between 950° C. to 1050° C.) either in the cooling or the reheating until brought to a temperature between about 800° C. to 1075° C., and, if then rapidly cooled, it will be tough and strong.

In the practice of my present invention, I substantially avoid the difficulties incident to slow cooling and incident to slow reheating of the partially formed product. This practice includes the feature that, where it is feasible to do so, the partially formed product should be placed in the reheating furnace before there has been any substantial separating out of its carbids at temperatures above 950° C. Also, if, for any reason, the partially formed shape must be cooled after the first forming operation and from above 950° C. and to a lower temperature (as, for example, if it must be cooled down entirely from 1100° C. until cold before it is reheated for further forming,) it is then a characteristic feature of the invention that such cooling is effected rapidly from the rolling temperature to below 950° C. and preferably to below 640° C., below which temperature carbid separations are not important. The practice of my invention is likewise based upon the discovery that the reheating of the rapidly cooled preliminary product should be conducted rapidly through a range beginning with about 400° C. upwardly to the maximum furnace temperature for the subsequent step intended.

I have found that by the expedient of rapidly cooling the preliminary wrought product, as a preparatory step to the rapid reheating thereof, the separation of carbids and loss of the wrought state of the metal is substantially avoided, so that the wrought condition in which the broken austenite grains are still present and wherein the carbids are uniformly distributed in the grains, is substantially maintained at the termination of the rapid cooling operation. So also, I have found that this desirable uniform distribution and retention of the carbids within the grains of the metal persists during the rapid reheating and that when a temperature of about 800° C. is reached, the broken austenite grains are reformed, without losing the uniform distribution of the carbids, into a uniform austenite structure. However, as the temperature rises, the grain size increases and the strength of the metal when cold decreases, and the temperature for the reheating of finished shapes not further to be wrought as above described is preferably limited to a temperature not above 1075° C.

The rapid cooling of thin preliminary shapes, such as sheet bars, which are afterward to be reheated, may consist in quenching by immersion in water from the heat of rolling; or the result will be satisfactory if the rapid cooling of the sheet bar is effected, by means of a light water spray, (for example, until at a temperature at or below 950° C. but preferably at or below 420° C.) so that the sheet bars will be tough and may be smoothly and exactly cut by shearing.

Heavy wrought shapes such, for example, as thick plate slabs, which are to be reheated for further forming, would be given a condition of severe strain by quenching by immersion in water, and would be liable to rupture if immediately reheated rapidly. Therefore, the rapid cooling of such heavy shape is preferably effected as they leave the rolls, by applying a water shower until the steel is at or about a black heat.

Having thus described my invention, what I claim is:

1. The method of producing wrought shapes of manganese steel, which comprises heating the blank until in a uniform austenite state; forming; and cooling rapidly to below 950° C.; substantially as described.

2. The method of producing wrought shapes of manganese steel, which comprises heating the blank until in a uniform austenite state; forming; cooling rapidly to below 950° C.; reheating rapidly; further forming; and cooling rapidly to below 950° C.; substantially as described.

3. The method of producing wrought

shapes of manganese steel, which comprises heating the blank until in a uniform austenite state; forming; cooling rapidly to below 950° C.; rapidly reheating to between 800° C. and 1075° C. to regrain the steel; and cooling rapidly to below 950° C.; substantially as described.

4. The method of producing wrought shapes of manganese steel, which comprises heating the blank until in a uniform austenite state; forming; cooling rapidly to below 950° C.; rapidly reheating to between 975° C. and 1075° C. for a short time to restore the carbids of the steel to solution; and cooling rapidly to below 420° C.; substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

WINFIELD S. POTTER.

Witnesses:

JOHN C. PENNIE,

MINERVA LOBEL.