UNITED STATES PATENT OFFICE.

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PRODUCING ROLLED SHAPES OF MANGANESE STEEL.

1,017,904. Specification of Letters Patent. **Patented Feb. 20, 1912.**

No Drawing. Application filed October 30, 1911. Serial No. 657,397.

To all whom it may concern:

Be it known that I, WINFIELD S. POTTER, a citizen of the United States, residing in the city, county, and State of New York, have invented certain new and useful Improvements in Producing Rolled Shapes 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.

The object of my invention is to obtain reliably a rolled manganese steel rail or bar with a continuous fine grained austenite structure throughout; that is to say with the separable constituents of the metal in solution, and also with a continuous structure free from irregularities or lamination.

A suitable method for obtaining the finished rail or bar in the desirable fine-grained condition is set forth in my application for Letters Patent of the United States, Ser. No. 604,996, filed January 27th, 1911, for improvements in the heat treatment and rolling of manganese steel.

I have found, in practice, that, in some instances because of the character of the mill or particular conditions and exigencies attendant upon its operation, the rail or bar after leaving the finishing passes in the desirable condition suitable for immediate quenching or like rapid cooling is subject to delay in reaching the quenching tank so that alterations begin to manifest themselves in the rolled product in the shape of a partial separating out of the constituents which had been in solution throughout the metal, this separating out being particularly prominent in the thinner sections of the rail or bar. The rail or bar, in such cases, correspondingly loses the uniformity of condition which it has been the purpose of the treatment to attain, and if quenched or otherwise rapidly cooled in its altered condition will have these irregularities retained or made permanent in the completed product.

One of the purposes of my present invention is to restore to the condition suitable for quenching or rapid cooling a rail or bar which after leaving the finishing pass of the rolls, has suffered in some of its parts the separation referred to, so that thus restored and thereupon quenched or rapidly cooled, it will, as a final product, have the same continuous fine grained austenite structure free from irregularities or laminations and with its separable constituents in solution throughout substantially the same as if it had been immediately quenched or rapidly cooled upon its issuance from the finishing passes of the mill.

The method herein described further contemplates the avoidance of lamination in the rolled product by so conducting the manufacture that the ingot or bloom is prepared for rolling without a formation of very large grains having smooth surfaces and feeble cohesion, such feeble cohering grains if present being elongated during rolling into fibers or sheets, which also have but feeble cohesion one with the other.

In the practice of the invention, the steel, containing the desired high proportion of manganese, carbon and other elements, as for example, containing 13% of manganese, 1.25% of carbon, is so cast as to obtain a sound ingot free from pipes. This may be effected, for example, by using molds whose top section is of refractory material, or of chills thinner than the chills employed in the lower parts of the mold; so that the metal remains molten longest in the upper portion of the ingot. So also, the steel is preferably cast at a temperature not much above the freezing point of the metal so as to further minimize piping and so as to minimize segregation. A mold having suitably proportioned chilling capacity and regulated conduction and radiation of the heat of liquefaction of the metal, as described in Letters Patent of the United States, No. 967,830, granted to me under date of August 16, 1910, is also preferred so as to render the temperatures in the ingot higher and more uniform at the time suitable for stripping than would be the case if the ordinary heavy iron mold were used.

When the ingot is frozen and has suitably cooled, depending upon the character of the mold employed, the ingot is stripped and is placed in a furnace which, at the time, has a temperature not far removed from the surface temperature of the ingot, and more especially is caution to be observed in this particular if the ingot shall have retained any of its freezing structures when stripped. The ingot is then brought to a temperature of about 1200° C. and heated until in a plastic and uniform condition such that it may be readily rolled for the production of a bar or bloom of continuous and homogeneous character. The heating of the ingot to bring it into the plastic and uniform condition desired and with the avoidance of lamination in the finished product is proceeded with in such manner that the temperature rises to the maximum without any long rest in its progress particularly any long rest above 1125° C. When the maximum temperature is reached this maximum temperature is continued for such time only as to bring the mass to a uniform temperature without detaining the ingot in the furnace beyond this point, as by so doing coarse, feebly cohering grains would be formed in the ingot.

The rail or other bar to be rolled may be obtained direct from the ingot in a continuous operation, or by rolling in stages after reheating the bloom; according to the arrangement of the mill or the particular section of the rail or bar required. If conducted in stages, requiring the reheating of the bloom, the bloom is preferably taken quickly from the blooming mill to the reheating furnace while still retaining as much as possible of the initial heat in order to facilitate the reheating operation. The temperature of the reheating furnace at this time should closely approximate the intended temperature to which the reheated bloom is to be brought, so that the reheat may be of short duration, such as to avoid excessive crystal building in the bloom.

It may be here noted that an ingot which is finely recrystallized in the mold by redistribution of the heat of casting and which is then introduced with a high and nearly even temperature throughout into the soaking pit may be brought rapidly to a temperature and condition suitable for rolling in a short time and without the progressive building up of coarse, feebly coherent crystalline structures; and that similarly, the bloom which is placed in the reheating furnace with a high and nearly even temperature may be brought to a temperature and condition suitable for further rolling with the smallest degree of crystal building and in the state of substantial uniformity and continuity of structure, whereby the characteristic lamination of manganese steel rolled from a blank, which has been either too slowly heated or which has been over-heated may thus be avoided.

The temperature for the reheated bloom will depend largely upon the character and extent of the work to which it is to be subjected in the finishing passes of the mill, and may range from as low as 1000° C. in those instances where the bar is to receive but one or two additional passes and is then to be immediately quenched, up to say 1225° C. in case the percentage of reduction to the finished section is still considerable and the shape to be produced is of such design that the greatest plasticity of the bloom is requisite.

To obtain in the finished bar a state of maximum strength and toughness, the finishing temperature, as the bar leaves the finishing pass of the mill should be as uniform as possible and as near 950° C. as possible, provided that the bar is thereupon immediately quenched. At all events, the parts of the bar that are to be subjected in use to wear, as, for example, the head portions of a rail should be rolled and quenched while the temperature is below 1075° C. or thereabout to secure a fine grained dense steel, and these parts, as for example, the hotter head-portion of a rail should be speedily cooled to about 1000° C. thereby so equalizing the temperatures as to avoid changes in the wrought state due to slow air cooling from higher temperatures; and the bar may be quickly brought to the water and quenched, in accordance with my application for Letters Patent of the United States, Ser. No. 604996, while still in a fine grained stiff and uniform condition. If the arrangements in the mill, or the character of the section is such that the rail or bar can not be reliably brought to the water while still having its separable constituents in solution and while still retaining throughout the desirable uniformity of temperature and condition, the finished bar should be taken as speedily as possible and with the least possible loss of temperature and change in condition to a reheating furnace (of the continuous type, for example) and therein equalized at about 1000° C. throughout and then quickly removed and quickly quenched.

The temperature at which the re-solution of the carbids of iron and manganese can be quickly effected ranges from about 975° C. upward. The higher the temperature of the reheating furnace, the shorter is the time required to bring the steel to temperatures above 975° C., when the carbids will be quickly taken into solution. I have found that the higher the temperature to which the steel is brought the more rapidly is it recrystallized, and the size of the grain registers the highest temperature at which any portion of the mass is permitted to rest even for so short a time, for example, as 10 minutes; and this recrystallizing, if permitted, may even destroy entirely the fine wrought state of the bar previously obtained during the rolling operation. It is therefore very important that the finished bar shall not be reheated throughout and allowed to rest in the reheating furnace long at any high temperature, and particularly at temperatures above 1075° C. or thereabout, above which point the bar if brought to an equal heat and allowed to rest soon assumes throughout a coarse grained excessively ductile and a weak and unreliable condition.

The reheating or equalizing furnace may be of the usual type, that is to say, a furnace having a hearth on which the bars are to be placed and having a reverberatory roof and a heating medium or flame below the roof, so that the bar is heated by radiation from the flame and from the roof. The reheating of the finished bar will be best conducted substantially as follows: The bar to be reheated (being for example, a T-rail or a girder rail), having still from the heat of rolling, a temperature in its thicker head portion sufficient to retain in solution the separable constituents of the steel, and having so far cooled in its base as to be in an unsuitable state for quenching, will be placed on the hearth of the equalizing furnace head downward, or on its side with the head inclined downward, so as to expose the cooler parts of the rail to the radiation from above. The flame and roof temperature of the furnace is maintained preferably at about 1025° C. so that the bar may remain in the furnace for a few minutes after its temperatures have become equalized without considerable alteration of structure other than the desired re-solution of carbids and for such time as will surely effect such solution. The bar, leaving the mill at say 1025° C. in its hottest portions and at say 950° C. in its coolest portions will move to the furnace in say 30 seconds with a loss of about 50° C. in its average temperature. Its coldest parts may then have a temperature below 900° C. and these coldest parts will have begun to suffer a separation of carbids and a transition from a uniform austenite structure. The bar being placed in the equalizing furnace without further loss of time is brought back to say 1000° C. in about 5 minutes and may then be quenched at once, or it may be detained in the furnace for say 5 additional minutes to more nearly equalize its temperatures before quenching. After obtaining an equal temperature above 975° C. or thereabout no additional stay in the furnace is necessary or advisable, inasmuch as immediately after solution of the carbids is complete, grain building would begin with a rapid loss of stiffness, hardness and strength of the steel. In fact, these objectionable changes proceed so rapidly at 1100° C., for example, that as short a delay as one minute after the bar has been equalized at this point is enough to cause a considerable loss of quality. The bar should, therefore, be kept in the furnace under a rapidly rising heat until its temperatures are nearly or quite equalized above 975° C. throughout the bar, and the carbids will then be in solution whereupon the bar should be immediately removed and quenched. In those instances when the bars reach the equalizing furnace hotter or colder than as above described, the time of subjecting them to the action of the equalizing furnace may be correspondingly shortened or lengthened, as the case may be and as may be necessary to restore the coldest parts to the desirable uniform condition; whereupon the bars will be removed from the equalizing furnace and quenched or rapidly cooled to below 420° C.

Having thus described my invention what I claim is:

1. The method of producing rolled shapes of manganese steel, which consists in first heating a manganese steel ingot or bloom until it is in a condition of substantial uniformity of distribution of its constituents, rolling to finished shape with finishing temperatures below 1075° C., transferring to an equalizing furnace and subjecting it to an equalizing reheat therein at such temperature as will effect the re-solution of any carbids that may have separated and until such resolution has been effected, terminating the equalizing reheat before any substantial loss of the wrought condition has occurred, and then quenching; substantially as described.

2. The method of producing rails of manganese steel, which consists in first heating a manganese steel ingot or bloom until it is in a condition of substantial uniformity of distribution of its constituents, rolling to finished shape with finishing temperatures below 1075° C. in the parts of the rail that are to be subjected in use to wear, transferring to an equalizing furnace and subjecting the rail therein to an equalizing reheat at such temperatures as will effect the resolution of any carbids that may have separated and until such re-solution has been effected, terminating the equalizing reheat before any substantial loss of the wrought condition has occurred and then quenching; substantially as described.

3. The method of producing rails of manganese steel, which consists in first heating an ingot above 1125° C. until in a uniform coherent condition, rolling to a bloom, reheating the bloom and equalizing for a short time at temperatures between 1000° C. and 1225° C., rolling to a rail with a finished temperature below 1075° C., equalizing for a short time, and quenching; substantially as described.

4. The method of producing rails of manganese steel, which consists in first heating an ingot above 1125° C., until in a uniform coherent condition, rolling to a rail with a finishing temperature below 1075° C., equalizing for a short time, and quenching; substantially as described.

5. The method of producing rails of manganese steel, which consists in first heating an ingot above 1125° C. until in a uniform coherent condition, rolling to a rail with a finishing temperature of about 950° C.,

equalizing for a short time at about 975° C. to 1025° C., and quenching; substantially as described.

6. The method of producing rails of manganese steel, which consists in first heating an ingot above 1125° C., until in a uniform coherent condition, rolling to a rail with a finishing temperature below 1075° C., equalizing the temperatures of the finished rail at about 1000° C., and shortly thereafter quenching; substantially as described.

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

WINFIELD S. POTTER.

Witnesses:
JOHN C. PENNIE,
M. A. BILL.