UNITED STATES PATENT OFFICE.

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PROCESS OF ROLLING MANGANESE STEEL.

938,803. Specification of Letters Patent. Patented Nov. 2, 1909.

No Drawing. Application filed May 15, 1907. Serial No. 373,837.

To all whom it may concern:

Be it known that I, WINFIELD S. POTTER, a citizen of the United States, residing at Mahwah, in the county of Bergen and State of New Jersey, have invented a certain new and useful Process of Rolling Manganese Steel, of which the following is a specification.

The object of this invention is to produce finished shapes from manganese steel by rapid reductions through machines of ordinary construction and without impairing the characteristic quality of the material.

Heretofore it has been extremely difficult to roll or work even small plain shapes of manganese steel with rolls of ordinary construction. I have discovered, however, that by rolling the ingot, bloom, billet, blank, or mass of metal to be shaped at certain temperatures under certain conditions, and subjecting the same to certain steps in the process, that irregular shapes having a considerable area in cross section, such as railroad rails, may be rolled with machines now in use for rolling Bessemer steel rails, and without destroying or impairing the characteristics and quality of the manganese steel.

The ingot or bloom, if cold and in the ordinary cast condition, is first heated slowly to a temperature above 430° C., preferably to about 535° C., but under other conditions the temperature may be raised more rapidly to about 430° C., as for example, when the ingot or bloom has been so treated as to be tough and free from strains. If, however, the ingot or bloom is at a red heat, or is still hot from the heat of casting, a preliminary heating is of course unnecessary. The temperature of the ingot or bloom is then raised as desired to a point, hereinafter designated as the upper critical point, and which usually occurs at a temperature varying from 1010° C., to 1050° C., where the metal becomes weak and tender, and above which point the metal is easily ruptured under tension, or in consequence of rapid or unequal expansion in the heating furnace. The temperature is then raised evenly to below the melting point, which is about 1330° C., preferably to a temperature below 1250° C., where the metal becomes extremely fragile or brittle, for instance, to about 1230° C., the highest temperature depending upon the analysis of the steel, the form of the ingot or bloom, or the character of the rolls. For example, if the ingot, bloom or other body of metal is thin it is heated slowly and evenly, or if the bloom or blank is sufficiently thin to be heated uniformly throughout it may be heated in less time but at about the same rate in proportion to its thickness, to a temperature varying preferably from 1100° C., to 1250° C., for instance, to about 1150° C., provided the shape to be formed does not require considerable plasticity of the metal, and thereupon the skin or outer portion is cooled until at or below the temperature of the interior.

In case the ingot or bloom is of ordinary shape and thickness, the temperature above the upper critical point is raised slowly or evenly to prevent cracking, until the ingot or bloom is soft and plastic and is symmetrically heated to temperatures preferably from 1150° C., to 1250° C., for instance, to about 1230° C., and thereupon the temperature of the skin or outer portion is cooled until it is at or below the temperature of the interior. In case, however, the ingot is brought from the mold with its interior portion at a temperature from the heat of casting considerably above the upper critical point, for instance, about 1330° C., and with its outer portion having an uneven or irregular, but high temperature, as for instance, varying from 950° C., to 1150° C., then the outer portion is brought evenly to a temperature preferably above 1010° C., but below the temperature of the interior, which interior temperature will, at the same time, of course, be somewhat reduced, say from 1330° C., to about 1230° C. But if the body of metal is brought from the mold with its interior temperature slightly above the upper critical point, for instance, 1100° C., and its outer portion having an uneven or irregular but high temperature, for instance, varying from 700° C., to 900° C., then the body of metal is heated evenly until in a soft and plastic condition, and to a temperature for instance about 1250° C., whereupon the skin or outer portion is evenly cooled to a temperature at or below the temperature of the interior. In case, however, the body of metal is hot from the heat of casting, but the interior temperature is below the upper critical point, as for instance, 950° C., and the outer portion for instance at 500° C., to 700°

C., then the body of metal as a whole is evenly brought to the highest predetermined temperature, for instance, 1250° C., and the skin or outer portion is thereupon cooled preferably to a temperature the same as, or below, the interior temperature to thereby render the same strong and tough, as already described in the case of the ingot or bloom of ordinary shape and thickness.

When the ingot is taken from the mold with a temperature throughout above 700° C., as before described, and which is a temperature above the recrystallization point, the metal is in what may be termed an amorphous plastic state, by which I mean, a state wherein the metal is free from crystals, and which state or condition is hereinafter referred to as the amorphous condition. Also when the ingot is taken from the mold at a temperature above 700° C. throughout, or when the ingot has been reheated to the highest predetermined temperature, as before stated, for example to 1250° C., and when neither cracks, crystals nor crystalline forms are present in the ingot or body of metal, said ingot may be described as being in an uninterrupted or continuous amorphous condition. The ingot, or mass of metal to be worked, is then passed through the blooming mill, roughing rolls, cogging rolls, or subjected to the action of a hammer or press, as desired. The initial passes of the ingot through the blooming mill, roughing or cogging rolls, are preferably comparatively slight, especially so when the skin temperature is at or above the upper critical point, and in that case, the first passes should preferably be executed in a box or Gothic pass, or some pass which will compress the metal of the ingot toward the center from all points at the same time, and exert a substantially uniform pressure upon opposite sides of the ingot or bloom whereby the skin will be converted into a wrought condition prior to any substantial reduction of the ingot or bloom.

In case a hammer or press is used, the ingot is preferably reduced slowly at first in order to compress and set the surface of the metal comprising the same without substantial reduction of the ingot or bloom. The ingot or bloom is then subjected to the action of rolls, hammer or press, and if the finished shape desired is substantially the same as that of the bloom or ingot, or if the temperature thereof has been only slightly reduced by the initial treatment in the rolls or under the hammer, then the ingot may be passed directly to the finishing mill. In case, however, the finished shape to be produced differs considerably in form from that of the ingot or bloom, or if the percentage of reduction from any one pass to the succeeding pass in the finishing mill is large, and the temperature has so fallen that the necessary ductility no longer exists, the ingot or bloom, after leaving the roughing rolls, is placed in a furnace of any suitable type and carefully and evenly reheated, to such a temperature as will impart the necessary ductility, for example, to temperatures above 1150° C. in its interior portion. The skin or outer portion of the bloom is then preferably cooled slightly below the temperature of the interior portion of the bloom, which is then subjected to the action of the finishing mill and is rolled or hammered to shape; for example, if the interior temperatures are above 1150° C., the outer portion is preferably brought to a slightly lower temperature, as for example, 1120° C. If, however, the interior temperatures are between 1200° C., and 1300° C., then the outer portions are preferably brought to temperatures below 1175° C., say, for example, to 1150° C., one purpose and result of the lowering of the temperature of the outer portion of an ingot or bloom being to lend thereto a skin or outer portion of such strength and toughness that the interior portion will be caused to flow without rupture to any portion of the mass when under pressure while being worked. The reduction of the temperature of the skin or outer portion is preferably accomplished by subjecting the body of metal to the action of gas or vapor, and immediately preceding the working of the metal.

When the temperature of the ingot or bloom is raised very gradually and steadily, a much higher temperature is permissible than when the same is subjected to the action of the rolls or hammer with considerable inequalities of temperature in different parts thereof. To produce the best results, it is necessary that the interior portion of the ingot or bloom shall be at, or substantially at, the same temperature throughout its length, and that the outer portion or surface thereof shall be at the same or a lower temperature than the interior portion. The cooling of the outer portion or skin tends to compress the metal in the interior of the ingot or bloom and to work the skin metal, and slight reductions in the first passes through the rolls or under the hammer also tend to compress and set the metal, so that it is possible to raise the ingot or bloom to higher temperature than is otherwise possible without destroying the characteristics of the metal. The heating of the ingot or bloom should preferably be carried on in a non-oxidizing fluid to maintain the skin intact, and to prevent the rupture of the ingot or bloom while in the furnace, or the cracking of the bloom in the process of rolling.

If the greatest toughness in the metal be desired, the finished shape, if at or above a red heat, may be quenched in water, or if necessary, may be reheated and quenched in the ordinary way.

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

1. The process of forming shapes from manganese steel ingots or blooms which consists in working the same while the interior thereof is in a soft and plastic condition and at temperatures above the upper critical point and the outer portion in a strong and tough condition.

2. The process of forming shapes from manganese steel ingots or blooms, which consists in working the same while the interior thereof is in a soft and plastic condition and at temperatures above the upper critical point, and the outer portion in a strong and tough condition at temperatures not above those of the interior.

3. The process of forming shapes from manganese steel ingots or blooms which consists in giving the interior of the ingot or bloom a temperature above the upper critical point and the skin a temperature below the temperature of the interior, and then reducing the ingot.

4. The process of forming shapes from manganese steel which consists in providing a strong and tough skin on a body of manganese steel having a soft and plastic interior, and reducing said body of metal.

5. The process of forming shapes from manganese steel which consists in providing a strong and tough skin on a body of manganese steel having a soft and plastic interior, and then reducing said body of metal while the interior thereof is at a temperature above the upper critical point.

6. The process of forming shapes from manganese steel which consists in imparting to a body of said metal having a soft and plastic interior, a skin of such strength and toughness as will cause the interior portion of said body to flow while under pressure and without rupture to said body, and then reducing said body of metal.

7. The process of forming shapes from manganese steel which consists in heating the body of metal to a substantially uniform temperature above the upper critical point throughout, then cooling the outer portion of said body of metal to toughen and strengthen the same, and then reducing the said body of metal.

8. The process of forming shapes from manganese steel which consists in heating the body of metal to temperatures above the upper critical point, maintaining the heat at or above the upper critical point until the temperature of the interior of said body of metal is substantially uniform, and subsequently reducing.

9. The process of forming shapes from manganese steel which consists in heating the body of metal throughout to temperatures below the upper critical point, then heating the body of metal evenly to temperatures above the upper critical point, and below the melting point, maintaining the heat until the temperature of the interior of said body of metal is substantially uniform, and subsequently reducing.

10. The process of forming shapes from manganese steel which consists in heating the ingot or bloom slowly and evenly from temperatures at or above 1010° C. to temperatures above 1100° C. and below 1300° C., and subsequently reducing.

11. The process of forming shapes from manganese steel, which consists in evenly heating the body of metal from temperatures at or above the upper critical point, until soft and plastic, and subsequently reducing the body of metal.

12. The process of working manganese steel which consists in slowly and evenly heating a body of manganese steel from temperatures at or above the upper critical point until the interior thereof is soft and plastic, then providing the same with a tough skin having a temperature lower than the temperature of the interior, and subsequently reducing the body of metal.

13. The process of forming shapes from manganese steel which consists in evenly heating the body of metal in a non-oxidizing fluid from temperatures at or above the upper critical point, until soft and plastic, and subsequently reducing the body of metal.

14. The process of forming shapes from a body of manganese steel which consists in heating the metal to temperatures above the upper critical point, subjecting said body of metal to the action of a non-oxidizing fluid while the interior portion of said body is at such temperatures, and while soft and plastic, and subsequently reducing said body of metal.

15. The process of forming shapes from a body of manganese steel which consists in heating said body to temperatures above the upper critical point in a non-oxidizing fluid, then cooling with gas the outer portion of said body to a temperature below that of the interior, and subsequently reducing said body of metal.

16. The process of forming shapes from manganese steel which consists in imparting to a body of said metal while in a continuous amorphous condition throughout, and at temperatures above 1050° C., a strong and tough outer portion of skin, whereby said body of metal may be worked without rupture, and then reducing said body of metal.

17. The process of forming shapes from manganese steel which consists in heating a body of said metal while in a continuous amorphous condition from the heat of casting until the same is symmetrically heated, and subsequently reducing said body of

metal while at an average temperature above 1100° C.

18. The process of forming shapes from manganese steel which consists in heating the ingot while in a continuous amorphous condition from the heat of casting until the interior portions have an average temperature above 1150° C. and below 1330° C., bringing the temperatures of the outer portion above the upper critical point but below 1150° C., and subsequently reducing said ingot.

19. The process of forming shapes from manganese steel which consists in subjecting to heat an ingot having interior temperatures approximating the melting point from the heat of casting until the outer portion of said ingot is brought to temperatures between the upper critical point and 1150° C. and until symmetrically heated, and then reducing said ingot.

20. The process of forming shapes from a body of manganese steel in a continuous amorphous condition, which consists in toughening the outer portion thereof to prevent rupture, and then working the same without substantial reduction, and then reducing the body of metal.

21. The process of forming shapes from manganese steel ingots or blooms, which consists in converting the skin of the same without substantial reduction into a wrought condition while the interior thereof is in a soft and plastic condition, and at a temperature above the upper critical point, and then reducing the ingot or bloom

22. The process of forming shapes from manganese steel ingots or blooms, which consists in giving the interior portion of the ingot or bloom temperatures above the upper critical point, and the outer portion temperatures below those of the interior, working the ingot or bloom without substantial reduction, and then reducing the ingot or bloom.

23. The process of forming shapes from a body of manganese steel wherein the interior temperature is above the upper critical point, which consists in subjecting said body of metal to reduction by a substantially uniform peripheral pressure while the interior is soft and plastic, and then reducing the body of metal.

24. The process of forming shapes from a manganese steel ingot or bloom having its interior at temperatures above the upper critical point, which consists in treating the ingot or bloom so that the outer portion or skin thereof shall be tough and of uniform temperature, and then subjecting the ingot to reduction by substantially uniform peripheral pressure.

25. The process of forming shapes from a body of manganese steel having its interior portion at temperatures approximating the melting point and its exterior portion at irregular temperatures, which consists in bringing the temperature of the outer portion to a temperature above the upper critical point but below the temperature of the interior, and then reducing the body of metal.

26. The process of forming shapes from a body of manganese steel having an interior temperature approximating the melting point and an exterior temperature below the upper critical point, which consists in slowly heating the body of metal until its outer portion has a temperature above the upper critical point but below the interior temperature, and then reducing the body of metal.

27. The process of forming shapes from manganese steel which consists in heating the body of metal so that the interior temperature throughout is substantially uniform, toughening the skin of said body of metal, rolling said body of metal to a bloom, then re-heating said bloom to impart ductility, and then subjecting the bloom to the action of finishing rolls.

28. The process of forming shapes from manganese steel which consists in heating the body of metal to a substantially uniform temperature throughout, cooling the outer portion thereof, subjecting the body of metal to rolls to produce a bloom, reheating the bloom, cooling the outer portion thereof, and then subjecting the same to the action of finishing rolls.

29. The process of forming shapes from manganese steel which consists in evenly heating the body of metal to a substantially uniform temperature, cooling the outer portion thereof, subjecting the body of metal to a substantially uniform peripheral pressure, reheating the body of metal, then cooling the outer portion thereof and forming the same to its finished shape.

30. The process of forming shapes from manganese steel which consists in heating the body of metal in a non-oxidizing fluid to a substantially uniform temperature, cooling the outer portion of the body of metal to a temperature below that of the interior portion thereof, subjecting the body of metal to reductions, reheating the body of metal, cooling the outer portion thereof, and then forming the same to finished shape.

31. The process of rolling rails from manganese steel which consists in heating an ingot of said metal to temperatures above 1050° C. throughout, cooling the outer portion of the ingot, subjecting the same to the action of blooming rolls to form a bloom, reheating the bloom, and then rolling the bloom to its finished shape.

32. The process of forming shapes from manganese steel which consists in heating the body of metal until the interior portion thereof becomes soft and plastic, then re-

ducing said body of metal to its finished shape, and then quenching said finished shape in water to toughen the same without reheating.

33. The process of forming shapes from manganese steel which consists in giving the body of metal temperatures above 1100° C., subsequently rolling said body of metal to a finished shape, and then immediately quenching said finished shape in water.

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

WINFIELD S. POTTER.

Witnesses:
M. VAN NORTWICK,
JOHN B. WHITE.