

UNITED STATES PATENT OFFICE.

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METHOD OF PRODUCING WROUGHT SHAPES OF MANGANESE STEEL.

1,017,906.

Specification of Letters Patent.

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No Drawing.

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To all whom it may concern:

Be it known that I, WINFIELD S. POTTER, a citizen of the United States, and residing in the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Methods of Producing Wrought 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 present invention relates to the production of wrought shapes of manganese steel, and particularly to the conditions under which the steel should be cast, heat treated, worked, and finally quenched or otherwise rapidly cooled, to give a final product of a dense, tough, fine-grained, uniform, crystalline structure throughout, substantially devoid of laminations.

The main characteristic features of the invention consist in so conducting the heating operations to which the manganese steel ingot is subjected before working, that a condition of feeble cohesion or separation of grains, readily incident to the improper heating of manganese steel, is avoided, while the necessary ductility is imparted to the ingot to permit it to be effectively worked at the temperatures intended, and particularly so that in the final working of the steel to finished shape, the finishing stage of the working shall lie within a range where there is no rapid recrystallization of the metal, whereby the fine consolidated crushed-grain condition obtained during the working of the metal is retained in the final product; or the crushed-grain condition in the final product can be converted into a finely regrained austenitic structure, as will hereinafter more fully appear. So also, it is a particular merit of the invention that the metal throughout the entire series of steps up to and including the final forming lies within a reasonably narrow range of temperature with respect to that at which the ingot is stripped, whereby not only are the heating and equalizing operations conducted in relatively short periods of time, but the manufacture as a whole is very materially speeded up for a given quantity of output.

A further feature of the preferred practice of the invention relates to the conditions under which the manganese steel ingot is

cast and consists in pouring or teeming the manganese steel into the ingot mold at a low temperature approximating the freezing point of the metal, and in freezing and cooling the metal under such conditions that the ingot will attain in the mold a nearly uniform high temperature, thereby correspondingly lessening the period of detention of the ingot in the next succeeding or equalizing stage of the operation, which stage is intended to bring the metal to a substantially uniform strong austenitic structure throughout.

In order to obtain to advantage the cast condition of the ingot most appropriate to the practice of the invention, the manganese steel is prepared in liquid form ready for casting by mixing in a ladle deoxidized steel, having a suitable carbon content, with a proportion of liquid ferro-manganese or a quantity of metal containing a high percentage of manganese and of such analysis and in such proportions as to produce the desired manganese steel. Fluxing materials, such as silica or silicates, fluorspar, chlorid of sodium, lead oxids, or lime, are so added to the furnace charges before these are poured into the ladle, or to the mixture in the ladle, as to render fluid the oxids which may be entangled with or dissolved in the metal, and the charge of molten steel is held in the ladle for such time as may be necessary to effect the flotation of the impurities out of the mass. Manganese steel of an analysis quite suitable for the invention may contain say 12 per cent. to 13 per cent. manganese, and 1.10 per cent. to 1.40 per cent. carbon, or the steel may be varied in its properties by the addition of other alloying metals, such as chromium, or copper. The manganese steel, suitably deoxidized in the manner described, or in any other suitable way (as, for example, by adding in the ladle suitable deoxidizing aluminum alloys, or ferro-alloys) is poured or teemed into the ingot mold at a temperature but slightly removed from its freezing temperature which, for manganese steel of ordinary composition, will approximate 1350° C. The pouring or teeming temperature of the metal should not be more than say 100° C. above its freezing point, and if the metal has a temperature much above 1450° C. it should be cooled before pouring, so that its temperature will be within the range of from 1350° C. to about 1450° C. In order to effect this cool-

ing, a portion of the alloy metal required to produce the intended analysis may be added as hot or cold lump metal, or a suitable proportion of manganese steel scrap may be charged into the ladle either in the cold state or as heated pieces. The manganese steel, having the suitable low casting temperature is now poured into the ingot molds and its manner, rate and extent of cooling in the molds is so regulated or predetermined that, as the ingot forms, its lower portion begins to solidify before the upper portion, so that that part of the uppermost portion of the ingot to be subsequently discarded on account of the shrinkage cavities may be definitely determined and minimized. To cause the lower part of the ingot to precede the upper part in freezing or setting, it will be found convenient to provide the molds with a bottom plate of metal to receive the impact of the poured steel as it enters the mold, and also with peripheral walls of metal extending upwardly within the mold to the desired height. The metal bottom should rest upon a body of fire brick or like refractory material of low heat conductivity, and the peripheral walls should have a like backing, and the metal bottom and metal walls should be of a thickness so calculated that they will serve temporarily as a chill, but after having exercised their chilling effect will be heated by conduction from the interior of the ingot to a high temperature by the outward flow of heat from the interior of the ingot. So also, after the ingot has set, its top may be covered with a layer of dry sand, or the like. The chilling capacity of the metal bottom and metal peripheral walls of the ingot, the non-conducting capacity of the outlying refractory material, together with the temperature of pouring are so chosen and adjusted with respect to each other that the ingot shall be finally brought while still in the mold to a nearly equal temperature throughout, ranging preferably from about 1100° C. to about 1225° C., it being within the province of the operator to so vary or regulate and determine the freezing and cooling conditions that the ingot will be nearly equalized in temperature in the mold at a heat which he will determine according to the character of the soaking pit available for his uses in the next succeeding step of the operation. The ingot thus nearly equalized in temperature in the mold will have but slight irregularities of structure and composition when stripped as compared with an ingot which would be produced by casting in the ordinary heavy iron molds with extensive cooling in the outer portions of said ingot at the time suitable for stripping, or as compared with an ingot which is poured at a temperature considerably above the freezing temperature of the steel. The stripped

ingot is now placed in a soaking pit or heating furnace for the purpose of bringing it throughout to an equalized temperature and so as to eliminate its remaining irregularities of structure and composition, and to bring it into a substantially uniform austenitic structure throughout and without any separation of or lack of cohesion between the grains of its recrystallized structure. If the soaking pit available is substantially devoid of means for being heated other than by the heat of the hot ingots charged, the operator will have so regulated the rate and extent of cooling of the ingot in the ingot mold that it will attain therein a nearly uniform average temperature of say 1225° C. or such temperature that being now immediately placed in the soaking pit, it will be brought to a uniform temperature throughout of about 1175° C. (or to such temperature above 1125° C. as will afford the required ductility) by a further equalizing and redistribution of its heat already approximated in the ingot when stripped. If, on the other hand, the operator has at his disposal a soaking pit provided with facilities for obtaining by reheating from lower heats a suitably high temperature, it will be appropriate for him to so regulate the rate and extent of cooling of the ingot that it will be nearly equalized in temperature in the mold at say 1100° C., whereupon the stripped ingot may be placed in the soaking pit and by raising the temperature therein, the ingot will in a short time be brought to and equalized and retained at a temperature throughout of from 1125° C. to 1225° C., depending upon the ductility required for the forming operation, until in a uniform austenitic condition. The effect of the equalization of the temperatures of the ingot in the soaking pit as described is to bring its separable constituents into solution and to redistribute them throughout the mass until a state of uniformity of structure and distribution of the contained elements is obtained, so that a substantially uniform continuous and firmly coherent austenitic structure results, the temperature of the ingot and the time during which the metal was permitted to remain at the high temperatures having been suitably restricted throughout the equalizing or heating operation, so that the crystals of the metal have not been caused to separate or to assume a feebly coherent condition. The metal is then worked and the working continued until the worked shape has a finishing temperature below 1075° C. or thereabout, and it should then be so rapidly cooled as to avoid separations in or recrystallization of the steel. By continuing the working of the metal until at temperatures below 1075° C. the wrought condition, that is, the fine crushed-grain condition of the steel incident to the working persists in

the cold state of the product finished below that temperature. At temperatures above 1075° C., as for example, at a temperature of 1100° C., the metal passing from the rolls, hammer or press, would immediately recrystallize and regrain itself and the fine crushed-grain condition due to the applied work and pressure would not be found in the finished product. So also, by continuing the working until the metal has temperatures below 800° C. or thereabout, a stiff strained condition would result, which would necessitate a reheating to suitably regrain the steel after the working stage, so that the metal quenched from the heat of working at a temperature, for example, of 600° C. (a temperature below the recrystallization range lying approximately between 640° C. and 720° C.) would be stiff and brittle, particularly if the working at temperatures substantially below 800° C. had been accompanied by rapid reductions or great pressure. When the final forming is effected at, and the product immediately quenched from a temperature within the preferable range of 900° C. to 1000° C. (and to the best advantage at approximately 950° C.) the maximum state of strength and density with toughness is produced. However, this condition can only be obtained by first bringing the metal to a state of uniformity, as already indicated, by heating to high temperatures and continuing such heating at temperatures for example, above 1125° C., until a uniform state of solid solution of the constituents is obtained. The wrought shapes produced in accordance with the procedure described will, when thus brought to finished form and condition, be of a substantially uniform and continuous crystalline structure throughout, and devoid of laminations. The avoidance of laminations in the final product requires that the operator should avoid in all of the heating operations any long periods of heating at a uniform temperature, particularly at temperatures above the melting point of the eutectic at about 1125° C. It is also inadmissible to heat the ingot to temperatures of 1250° C. or above, inasmuch, as by heating manganese steel above this temperature, the condition or state of the metal which causes lamination is invariably produced. That is to say, by long heating above 1125° C., or by heating for a shorter time at and above 1250° C., the crystal building proceeds rapidly as compared with other steels and the large resulting grains have smooth surfaces with but feeble cohesion one with the other. Furthermore, the crystals of the steel during a heating period of long duration at the high temperatures mentioned actually separate one from the other and during subsequent rolling or working of the steel the separated grains are imperfectly welded, so that recrystallization through

and across the imperfectly welded surfaces is impossible and a marked laminated condition of the finished product results.

When the finished shape cannot be conveniently produced in one operation, and when the bloom or other preliminarily wrought shape must be reheated for further working, excessive temperature and long periods of heating at temperatures above 1125° C. must in this case also be avoided in order to produce a product free from lamination. In order to accomplish this result, in accordance with the preferred procedure under the invention, the ingot is first brought to the higher temperatures already specified and is then quickly worked with the production of a bloom having an average temperature but little below the ingot temperature (for example, at a temperature of 1100° C. to 1150° C.) and the bloom is then quickly reheated as may be necessary to restore its ductility and is then further worked as desired. Also, when the steel has been reheated, a fine-grained state with a maximum strength of the finished product results only when the final working is executed so that the mass is worked throughout at temperatures which in the final stage of the working are between 900° C. and 1000° C. When the bloom or other preliminarily wrought shape must be cooled down below 1000° C. and say to a black heat or to a lower temperature, before being reheated for further forming, the preliminarily wrought shape may be cooled rapidly to below 640° C. to avoid changes in the mass during cooling and thereafter heated to such temperatures above 900° C. to 1000° C. as will enable the subsequent working to be completed within this range; or, if the preliminarily wrought shape has been slowly cooled after forming, it may be reheated to above 1125° C. in order to restore the state of uniformity lost by slow cooling, and thereupon worked at temperatures which in the final stage of working shall be between 900° C. and 1000° C., with the production of the maximum state of excellence in the finished product; or it may be finally worked throughout at any temperature between 800° C. and 1075° C. with the result that the product will have a fine-grained wrought condition throughout. The finishing temperature will, however, regulate the stiffness and density of the finished product provided that the finished shape is immediately quenched from the heat of final forming.

The quality and condition of the steel, whether the finished shape is produced in one or more operations, may be determined by heating after the final forming to any temperature above the finishing temperature and then rapidly cooling or quenching the finished shape. The maximum state of

excellence will be obtained from so reheating when in the reheating the metal is brought to a temperature of about 1000° C. and equalized at such temperature for a short time only. The effect of this reheating and equalizing is to change the fine crushed-grain condition to a uniformly and finely regained austenitic condition.

If the finished shape must be cooled after the final forming and before the final quenching or similar rapid cooling required to insure toughness of the product, the finished shape should be cooled to below 640° C., rapidly for example, in five minutes or less, from 1000° C. to say 600° C.; and should be reheated rapidly, as, for example in ten minutes, from the cooled condition to say 1000° C. and should then be detained in the furnace only until it has reached the selected temperature throughout for quenching, and immediately quenched.

If the ingot must be cast in the ordinary manner and is considerably cooled in its exterior portions before being placed in the soaking pit, the heating operation will then be preferably conducted as follows: The ingot will be placed in a soaking pit having a temperature of about 1000° C. and the furnace will be gradually brought to a temperature of about 1050° C. and the ingots equalized at that temperature, and the ingots will then be further carefully raised to a temperature throughout above 1125° C. and then held at such high temperature as may be necessary for the ductility required for working, only so long as to bring the metal into the uniform austenitic condition; and the ingot is then worked and the working continued until the finished shape has a temperature of about 950° C. and the product may then be immediately quenched, or may be quickly cooled and afterward reheated to say 1000° C. and then quenched.

Having thus described my invention what I claim is:

1. The method of working manganese steel blanks, which comprises heating the blank until it has obtained a substantially uniform, continuous and firmly coherent austenitic structure; working the blank while in that condition and finishing the working operation at temperatures which in the finishing stage are between 800° C. and 1075° C.; and rapidly cooling to avoid recrystallization and separation of the constituents; substantially as described.

2. The method of working manganese steel blanks, which comprises heating the blank until it has obtained a substantially uniform, continuous and firmly coherent austenitic structure; preliminarily working the blank while in that condition; reheating until substantially equalized at such temperatures as will permit the product to be worked at final temperatures between 800°

C. and 1075° C.; working the product to the shape intended; and rapidly cooling to avoid recrystallization and separation of the constituents; substantially as described.

3. The method of working manganese steel blanks, which comprises heating the blank until it has obtained a substantially uniform, continuous and firmly coherent austenitic structure; working the blank while in that condition and finishing the working operation at temperatures which in the finishing stage are between 800° C. and 1075° C.; and rapidly cooling to avoid recrystallization and separation of the constituents, the rapid cooling being preceded by rapidly reheating to an equalized temperature of about 1000° C.; substantially as described.

4. The method of working manganese steel blanks, which comprises heating the blank until it has obtained a substantially uniform, continuous and firmly coherent austenitic structure; preliminarily working the blank while in that condition and finishing the preliminary working at temperatures between 800° C. and 1075° C.; rapidly cooling to avoid recrystallization and separation of the constituents; reheating to not above 1075° C. so as to avoid loss of the fine-grained state, completing the working at temperatures which in the finishing stage are between 800° C. and 1075° C., and again rapidly cooling; substantially as described.

5. The method of working manganese steel blanks, which comprises heating the blank until it has obtained a substantially uniform, continuous and firmly coherent austenitic structure; preliminarily working the blank while in that condition; permitting the preliminarily worked shape to cool slowly; reheating the slowly cooled preliminarily wrought shape to above 1125° C.; finally working the preliminarily wrought shape to final form to restore the fine-grained condition at a temperature which in the finishing stage should be within the range of 800° C. to 1075° C.; and rapidly cooling; substantially as described.

6. The method of producing wrought shapes of manganese steel, which comprises teeming the metal at a temperature approximating its setting point; regulating the manner, rate and extent of cooling of the metal, so that the ingot will freeze and cool in the mold to a nearly equalized high stripping temperature approximating 1225° C.; further equalizing the temperature of the ingot and bringing the ingot to a substantially uniform strong austenitic structure at temperatures throughout approximating 1175° C.; quickly rolling the ingot to a bloom with a high average temperature approximating 1100° C. to 1150° C.; reheating to such a temperature as will give the product sufficient ductility to be worked at a final

temperature in the finishing stage of the working approximating 950° C.; working the bloom to the finished shape intended; and rapidly cooling to avoid recrystallization and separation of the constituents; substantially as described.

7. The method of producing wrought shapes of manganese steel, which consists in teeming the metal at a temperature approximating its setting point; regulating the manner, rate and extent of cooling of the metal so that the ingot will freeze and cool in the mold to a high temperature nearly equalized at approximately 1100° C.; further equalizing the temperature of the ingot until at a temperature approximating

1200° C.; quickly rolling to a bloom having a high average temperature approximating 1150° C.; reheating to such temperature as will permit the product to be worked at a final temperature in the finishing stage of the working approximating 950° C.; working the bloom to the shape intended; and rapidly cooling to avoid recrystallization and separation of the constituents; 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.