UNITED STATES PATENT OFFICE.

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METHOD OF TREATING ARMOR-PLATES.

No. 928,412. Specification of Letters Patent. Patented July 20, 1909.

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To all whom it may concern:

Be it known that I, SAMUEL S. WALES, of Munhall, Allegheny county, Pennsylvania, have invented a new and useful Method of Treating Armor-Plates, of which the following is a full, clear, and exact description.

My invention relates to the manufacture of face-hardened armor plates, and more particularly to the steps of heating and quenching for final water-hardening. In my pending application for Patent, Serial No. 401,702, filed November 11th, 1907, I have described and claimed a novel method of this character for treating armor plate, which consists in heating that face of the plate which is to be hardened to a hardening temperature and simultaneously cooling the back of the plate by forcing a cooling fluid upon it for the purpose of maintaining the back in the condition in which it was left by its immediately preceding metallurgical treatment, then chilling in any approved way, and whereby I produce a face-hardened plate having three layers, namely, a face-hardened layer, a back portion, and a relatively thin intermediate layer of annealed material. This intermediate layer occurs at the point or zone where the temperature changes from the water-hardening range to the temperature where no action takes place in quenching.

My present invention relates more particularly to the control of the position of this relatively thin intermediate layer of annealed material with respect to the faces of the plate, and also to the control of the thickness of this intermediate layer itself. It is obvious that the control of the position of this intermediate layer is of great importance, since such position controls the thickness of the face-hardened portion or layer of the plate; and it is also important to control the thickness of the intermediate layer itself within such limits that it will not impair to any material extent the strength of the back of the plate.

I have found that the position of this intermediate layer may be varied by varying the length of time during which the cooling fluid is applied to the back of the plate, and that the thickness of the layer may be controlled by varying the duration of the interval during which the cooling fluid is supplied. That is to say, by alternately applying the cooling fluid to and cutting it off from the back of the plate and by varying the ratio of the time during which the water is applied to the time during which it is cut off, and by also varying the duration of the interval during which the water is alternately applied and cut off, the position and thickness of this layer can be controlled within certain more or less exact limits.

In carrying out my invention, the face to be hardened is exposed in the furnace, directly to the heat, while the edges are protected by any convenient refractory material so as to force the heat to penetrate from the front surface only. At the same time the back is exposed to a positive cooling action such as a spray of water, steam, or other cooling fluid, which is forced against it. The application of this cooling fluid is interrupted at intervals, both the frequency of the interruptions, and the length of each interruption, depending upon the result which it is desired to produce, as hereinafter more fully explained. The effect of interrupting or cutting off this cooling fluid is to cause the heat during the interval of the interruption to penetrate deeper into the plate, or to gain relatively upon the cooled back portion; and when the cooling fluid is again applied, some of this heat is extracted, or in other words, the penetration of the heating is temporarily arrested and the back is again cooled down.

As hereinafter stated, I have found that the relative thickness of the chilled portion and the position of the intermediate layer in any particular plate will depend largely upon the ratio between the total time during which the cooling fluid is applied and the total time during which such fluid is interrupted. That is, the greater the total time of application of the cooling fluid relatively to the total time of its interruption, within certain limits, the thinner will be the hard face of the plate and the thicker its back portion. Therefore, to increase the depth of the hard face, the proportion of the time during which the water is applied should be diminished, and if it is desired to decrease the thickness of the hard face, the greater will be the proportion of time during which the cooling fluid is applied. Thus, with a plate which is six inches in thickness I have found that when the cooling fluid is applied during the entire time of treatment, a chilled portion of a thickness of from about a quarter to one-half inch may be produced, while by applying the cooling

fluid only during twenty per cent. of the time of treatment, this chill may be increased to a thickness of approximately two and a quarter inches. As stated, it is also of importance to control the thickness of the intermediate layer within such limits as not to materially detract from the strength of the back portion or layer of the plate, and this can be accomplished in all cases by varying the actual lengths of the intervals of application and interruption of the cooling fluid. Thus, in the instance above referred to of a six-inch plate, when the cooling fluid was applied during intervals of one-half of a minute each and was cut off for intervals of two minutes each, the thickness of this layer was from three-quarters of an inch to one inch, but when the intervals of application of the cooling fluid were increased to two and one-half minutes each, and the intervals of interruption to ten minutes each (which intervals it will be seen bear the same ratio to each other as in the first case), the thickness of the intermediate layer increased to approximately two and one-half inches.

In carrying out my process, the furnace is preferably heated at the start to a temperature of between ten hundred and twelve hundred degrees C., and the treatment may be required to continue for a period equivalent to 25 to 35 minutes for each inch thickness of plate. The surface of the plate should be heated preferably from 850° to 950° C., and in some cases it may be necessary to increase the time of treatment for each inch of plate sufficiently to reach these temperatures. The back is maintained by the application of the cooling fluid at a temperature such that no annealing can take place, and depending somewhat upon its previous metallurgical treatment. The plate is then removed from the furnace and water-quenched in the usual manner, as, for example, by spraying one or both faces of the plate with water. In this water-quenching the heated face of the plate receives its final hardness, while the back of the plate is not materially changed in its characteristics, on account of having been maintained at a much lower temperature than that of its final toughening treatment.

When a plate which has been treated according to my method is withdrawn from the furnace and chilled, it will be found to contain three different layers or zones, there being a strong back portion which maintains the characteristics imparted thereto by the last metallurgical treatment previous to heating for hardening, owing to the fact that the cooling of the back of the plate has prevented its temperature being raised to a point where any annealing can take place either during the heating process or during the subsequent quenching; a face-hardened portion in which the hardness is substantially uniform by reason of the uniformity of temperature therein, and by reason of the heating being practically limited to this portion of the plate, so that the total heat to be extracted is relatively small; and a relatively thin intermediate layer where the temperature changes from the water-hardening range to the temperature where no action takes place in quenching, and the position and thickness of which will depend upon the mode or manner of application and interruption of the cooling fluid in the manner above described.

While as above stated, I may use either water, steam, air or other cooling fluid, I have found the best results to be obtained by the use of water.

The fracture of a plate which has been treated in accordance with my invention may show three distinctly visible layers or strata corresponding to the three zones or layers above described. In some cases the division line between the middle layer and the main body or back of the plate may not be distinctly visible to the eye where the main body or back of the plate was annealed to the same condition before heating for water-hardening, as this strip will be after the process of heating for water-hardening. In case the body or back of the plate has been annealed to a soft condition, but still harder than this soft strip mentioned, the line of demarcation may not be visible to the eye, but it can be readily detected by physical tests taken successively from the back to the face of the plate. If the main body or back of the plate in its immediately preceding metallurgical treatment has been left in the condition in which the structure differs radically from that of the soft annealed strip, the three zones or layers will be distinctly visible to the eye in the fracture.

My present invention, while producing a plate having all the advantages described in my said application, has the added advantage of enabling me to control within very close limits the location and thickness of the intermediate zone or layer by controlling the two factors which determine the thickness and position of this layer, viz., the total time of application of the cooling fluid relatively to the total time of the interruption of the same, and the actual duration of the intervals of application and interruption, as described.

It will be understood that the thicker the plate to be treated the greater should be the total time during which the cooling fluid is applied, and that in order to keep the thickness of the intermediate layer or zone within the desired limits, the actual time of each interruption of the cooling fluid should be short. In practice I have found that each

interval of interruption should not be more than five minutes in length, and I prefer that they shall not exceed three minutes, although I do not of course limit myself to intervals of interruption of any definite length, since these will vary quite largely with the thickness of the plate and other conditions peculiar to each case.

My invention is of more particular advantage in connection with relatively thin plates, since with plates of a thickness of 12 inches or over, it will usually be preferable to maintain the cooling action on the back of the plate during substantially the entire period of treatment, as described in my said application.

I have herein stated that the face portion or layer of the plate will be of substantially uniform hardness throughout. This applies, however, only to plates which have not been face carburized previously to being treated as herein described, and in which the greater hardness of the extreme face is due to the increased carbon thereof and not to my method of treatment.

I claim:—

1. In the manufacture of face-hardened armor plate, the step which consists in heating that face of the plate which is to be hardened to a hardening temperature, simultaneously artificially cooling the back of the plate, and periodically interrupting the cooling action or effect; substantially as described.

2. In the manufacture of face-hardened armor plate, the step which consists in heating that face of the plate which is to be hardened to a hardening temperature, simultaneously artificially cooling the back of the plate, periodically interrupting the cooling action or effect, and controlling the length of each period of interruption; substantially as described.

3. In the manufacture of face-hardened armor plate, the method of treatment which consists in heating one face of the plate to a hardening temperature and simultaneously applying a cooling medium to the opposite face, interrupting such application periodically, and making the intervals of interruption and of application of the cooling medium of different lengths; substantially as described.

4. In the manufacture of face-hardened armor plate, the method of treatment which consists in heating one face of the plate to a hardening temperature and simultaneously applying a cooling medium to the opposite face, interrupting periodically the application of said medium, and controlling both the total time of interruption and of application of said medium relatively to each other and also controlling the length of each interval of interruption with respect to the length of the intervals of application; substantially as described.

5. In the manufacture of face-hardened armor plate, the method of treatment which consists in heating one face of the plate to a hardening temperature and applying a cooling medium to the opposite face during a portion only of the time of heating; substantially as described.

6. In the method of treating armor plate to produce a plate having a face-hardened portion or layer, a strong back portion, and an intermediate relatively thin layer of annealed material, the step which consists in applying a hardening temperature to one face of a plate, and simultaneously intermittently applying a cooling medium to the opposite face, and regulating the position of the intermediate layer by controlling the total time of interruption of the application of said medium relatively to the total time of its application; substantially as described.

7. In the method of treating armor plate to produce a plate having a face-hardened portion or layer, a strong back portion, and an intermediate relatively thin layer of annealed material, the step which consists in applying a hardening temperature to one face of a plate, and simultaneously intermittently applying a cooling medium to the opposite face, and regulating the thickness of the intermediate layer by controlling the length of the intervals of interruption; substantially as described.

8. In the method of treating armor plate, the step which consists in cooling one face portion of the plate, and simultaneously applying a hardening temperature to the opposite face portion, and interrupting the cooling action at substantially regular intervals and for a substantially definite length of time at each interval; substantially as described.

In testimony whereof, I have hereunto set my hand.

SAMUEL S. WALES.

Witnesses:
D. A. HAMILTON,
W. H. CORBETT.