UNITED STATES PATENT OFFICE.

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MANUFACTURE OF ARMOR-PLATES AND OTHER ARTICLES.

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To all whom it may concern:

Be it known that we, WILLIAM ARCHBOLD HARTLEY, late general manager, and BEDFORD HENRY DEBY, metallurgist, subjects of the King of Great Britain, both residing at Cyclops Works, Sheffield, in the county of York, England, have invented new and useful Improvements in the Manufacture of Armor-Plates and other Articles, of which the following is a specification.

This invention has for its object the manufacture of armor plates and other articles of a composite character, in which the face possesses extreme hardness and the remaining portions are ductile and tenacious.

In the ordinary process of armor plate manufacture, the above conditions are attained by a differential heating and cooling, so arranged that the face is raised to the hardening temperature while the remaining parts are kept much cooler. Afterward the face portion is sprayed with cold water. This procedure has the disadvantage of producing unequal strains in the finished plate.

According to the present invention, unequal strains are obviated in the following manner:—It is known that in order to induce the maximum degree of hardness in steel, it is necessary to heat the steel to a temperature in excess of the transformation or critical point of the steel. It is also known that certain classes of steel known as "perlitic" steels have two critical points namely that which occurs on heating and that which occurs at recalescence on cooling the latter being at a lower temperature than the former. In this specification for the sake of clearness the former will be termed the critical temperature and the latter the temperature of recalescence. The present invention takes advantage of these facts by employing a perlitic steel preferably one in which there is a considerable difference between the critical temperature and the temperature of recalescence and then first heating that portion of the plate which is required to be hard, to a temperature higher than the critical temperature of the steel, the remaining parts being kept much below this critical temperature. If now the hotter part of the plate be allowed to cool, the temperature of the remaining portions being at the same time permitted to gradually rise, and the whole be caused to equalize at a temperature well below the critical temperature but above the temperature of recalescence, the plate can be entirely immersed in, or sprayed with, a suitable chilling liquid, after which the portion of the plate which had previously been heated to a temperature in excess of the critical temperature, will be hard, and the remaining portions will be ductile and tenacious. Also on account of the equalized chilling temperature and uniform manner of chilling, all dangerous strains will have been avoided.

This process may be advantageously employed with compound plates in which the initial ingot is cast in two or more successive layers, the chemical composition of the two layers being different and such that the critical temperature of the face is considerably above that of the back. For instance the back of the plate may be cast of steel with a suitable proportion of nickel and chromium; immediately after the solidification of this alloy, the face portion—preferably containing certain porportions of molybdenum, chromium, tungsten or other special hardening elements, is cast on to one side of it, thus insuring a sound interfusion free from imprisoned oxids etc. The following percentages are suitable:—Face of plate:—Carbon .5 to 1.0%; chromium, tungsten or molybdenum, or any two or all three, 1.0 to 3.0%; nickel 2.0 to 6.0.%. Back of plate:—Carbon .10 to .30%; nickel 2% to 6%; chromium .75 to 3.0%; vanadium .25 to 1.0% separably or together. The compound ingot thus obtained is rolled, forged or pressed. The resulting plate is next heated to a hardening temperature and oil quenched. It is now reheated in such a manner that the desired thickness of the face portion will reach a temperature higher than the critical temperature of either of the alloys composing the plate, the remainder of the plate being kept considerably below that temperature; the temperature of the face portion is now allowed to fall while that of the back is raised and the whole is thus equalized at a temperature lower than the critical temperatures of the two alloys but above the temperatures of recalescence of the face; the plate is now uniformly chilled, either by immersion in, or spraying with, water or other suitable chilling medium. By this means the zone dividing the hardened from the unhardened portions of the face, is removed away from the line of interfusion of the face with the back; also by finally chilling the whole of the plate at a uniform temperature, unequal strains are avoided.

In carrying out this invention use is made of a suitable vertical expanding ingot mold. The back portion of the ingot is cast first, and immediately after the solidification of this alloy, the face portion is cast on to one side of it, thus insuring a sound interfusion, free from imprisoned oxids etc. The compound ingot thus obtained is rolled, forged or pressed. The resulting plate is next heated to a hardening temperature, *i. e.* above 800° C. and oil quenched. It is now reheated in such a manner that the desired thickness of the face portion will reach a temperature higher than the critical temperatures of either of the alloys composing the plate, *i. e.* from 750 C. to 900° C. The remainder of the plate being kept considerably below those temperatures say at about 550° C. This may conveniently be done by placing the plate face upward in a furnace in which the flames can play direct upon the face while the back and edges are protected by refractory material. The temperature of the face portion is now allowed to fall while that of the back is raised say by lifting the plate out of the protecting material, the temperature of the whole being thus equalized at a point lower than 750° C; the plate is now uniformly chilled, either by immersion in, or spraying with, water or other suitable chilling medium. By this means the zone dividing the hardened from the unhardened portions of the face, is removed away from the line of interfusion of the face with the back; also by finally chilling the whole of the plate at a uniform temperature, unequal strains are avoided.

What we claim is:—

1. In the manufacture of articles such as armor plates, heating a plate of perlitic steel in such a manner that a desired thickness of the face portion reaches a temperature higher than the critical temperature of the alloy of which the plate is composed while the remainder of the plate is kept considerably below that temperature, then allowing the temperature of the face to fall and raising the temperature of the remainder in such a manner that the temperature of the whole of the plate is equalized at a point lower than the critical temperature but above the temperature of recalescence and then uniformly chilling the whole of the plate substantially as described.

2. In the manufacture of articles such as armor plates which consists of two parts of differing composition, the face being of perlitic steel heating the plate in such a manner that a desired thickness of the face portion reaches a temperature higher than the critical temperature of either alloy of which the plate is composed while the remainder of the plate is kept considerably below the critical temperature of either alloy, then allowing the temperature of the face to fall and raising the temperature of the remainder in such a manner that the temperature of the whole of the plate is equalized at a point lower than the critical temperature of either alloy but above the temperature of recalescence of the face and then uniformly chilling the whole of the plate, substantially as described.

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Witnesses:
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