

UNITED STATES PATENT OFFICE.

SAMUEL S. WALES, OF MUNHALL, PENNSYLVANIA, ASSIGNOR TO CARNEGIE STEEL COMPANY, OF PITTSBURG, PENNSYLVANIA, A CORPORATION OF NEW JERSEY.

METHOD OF TREATING ARMOR-PLATE.

941,477.

Specification of Letters Patent. Patented Nov. 30, 1909.

No Drawing.

Application filed July 13, 1907. Serial No. 383,688.

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-Plate, of which the following is a specification.

Of recent years it has been the practice in the manufacture of armor plate to make the plate of steel having substantially the following theoretical composition:—carbon .28 per cent., manganese .35 per cent., nickel 3.75 per cent., chromium 1.70 per cent., the sulfur and silicon being low,—below .04 per cent. The steel of this composition is then treated by the Harvey or Krupp processes by which its surface is highly supercarburized for the purpose of rendering it more resistant to the impact of projectiles.

I have discovered a new alloy or composition and a new mode of heat treatment by which I am enabled to increase the ballistic resistance over that obtained by the alloys and treatments heretofore in use.

The elements which I alloy with the iron in order to produce my new composition are as follows, and in stating them I desire to premise that in addition to these elements others may be added if desired or the proportions may be varied within certain limits, those which I give being such as I have found best suited to the purpose:—Carbon .20 to .30 per cent., manganese .25 to .35 per cent., nickel 3.50 to 4 per cent., chromium 1.25 to 1.75 per cent., vanadium .10 to .25 per cent.

The steel which I employ is preferably open hearth steel and I prefer to add the nickel as a part of the charge of the furnace in a cold condition. I preferably preheat the chromium and add it to the open hearth charge just before tapping. The manganese is preferably added cold in the ladle and the vanadium is preferably added to the ladle in the form of preheated ferro-vanadium alloy. These alloys may however, be added in a molten form in the ladle or otherwise as desired. The proper portion of carbon may be added by recarburizing by the usual methods. The silicon contents of the steel should be low, less than .15 per cent. The sulfur should be as low as possible, preferably less than .04 per cent. It is extremely important in this vanadium alloy that the phosphorus should be extremely low because the vanadium is found to intensify the action

of this element. The phosphorus should not exceed .04 per cent.

Having cast the ingot and forged it at the ordinary forging temperature, if it is to be reformed it is subjected to a heat treatment in which it is raised to a temperature of about 700 degrees C., and cooled slowly, preferably in air. It may then be reformed at the usual reformatting temperature, and is then heated to a temperature above 875 degrees C. and preferably about 900 degrees C., which is higher than that to which the plates are reheated in the process now commonly in use. It is then quenched with water, the duration of the water treatment being preferably about one minute per inch of thickness, the time varying according to the chemical composition of the steel, being preferably somewhat less when the carbon content is higher. If the steel is not reformed, the heating to 900 degrees C., and the quenching will immediately follow the forging. A further toughness may be imparted to the plate, if desired, by repeating these steps of heating to about 900 degrees C. and quenching. The temperature of the plate will not be allowed to fall below 50 degrees C. during or after the quenching, in either case. If the plate were allowed to become atmospherically cold during or after the sudden cooling, it would be liable to crack internally. The steel is then annealed by raising it to a temperature above 675 degrees C., and below 725 degrees C., and preferably about 700 degrees C., and is then allowed to cool slowly, preferably in air, and may be rough-machined. Additional toughness is imparted to the plate by a second treatment consisting of again raising the temperature of the plate to about 700 degrees C. and allowing it to cool slowly preferably in the air. The temperature reached in this second heat treatment should be slightly lower than that in the treatment immediately preceding it. If the plate needs forming it is then reheated to a proper temperature and bent or straightened as desired. This temperature should preferably not exceed the temperature of the last preceding temperature. The plate is then finally machined and is ready for the final water hardening, which may be conducted in any suitable way. I prefer, however, to conduct this water hardening by raising the face to be hardened to a temperature of 900

degrees to 950 degrees C. This preferably is done while keeping the back of the plate at a somewhat lower temperature, although this is not essential as a difference in temperature need not be as great as is necessary in the ordinary standard nickel-chrome alloy now generally employed.

The advantages of my invention result from the increased ballistic resistance, the plates thus obtained being capable of resisting shocks better than the ordinary armor plates.

One of the advantages obtained by this alloy is that the fibrous character which is imparted to the plate during certain stages of the treatment is more persistent in character and is much harder to destroy by the following treatment which had heretofore destroyed it to a certain depth below the carburized face. With the ordinary nickel-chrome alloy, this fibrous character of the plate is destroyed by water hardening from a temperature at or above 775 degrees C. With my improved alloy, however, it has been found that the fibrous condition is retained throughout the body of the plate and up to that portion of the face where the carbon is above .50 per cent.

Another peculiar action of the vanadium in this alloy is found to be that it enables the proportion of chromium to be reduced. This is of great advantage since a large proportion of chromium is found to make the steel extremely sensitive to temperature changes and to shock. The vanadium intensifies the advantageous qualities produced by chromium, thus enabling a smaller amount to be used and doing away with the disadvantages which accrue from a large amount of chromium.

Those skilled in the art will be able to modify the steps of the heat treatment within certain limits without departing from my invention.

I claim:—

1. The method of making armor or ballistic steel plates, consisting in producing a steel plate, heating the plate to a temperature above 875 degrees C., and suddenly cooling it to between 350 degrees C. and 100 degrees C., and then annealing the plate; substantially as described.

2. The method of making armor or ballistic steel plates, consisting in producing a steel plate, heating the plate to a temperature above 875 degrees C., suddenly cooling it, again heating it to above 875 degrees C., and again cooling it, and then annealing the plate; substantially as described.

3. The method of making armor or ballistic steel plates, consisting in producing a steel plate, heating the plate to a tempera-

ture above 875 degrees C., and suddenly cooling it to between 350 degrees C. and 50 degrees C., and then subjecting the plate to two or more annealing operations; substantially as described.

4. The method of making armor or ballistic steel plates, consisting in producing a steel plate, heating the plate to a temperature above 875 degrees C., and suddenly cooling it to between 350 and 100 degrees C., then annealing the plate, then heating it to above 875 degrees C., and suddenly cooling it to blackness, and again annealing the plate; substantially as described.

5. The method of making armor or ballistic steel plates, consisting in producing a steel plate containing vanadium, heating the plate to a temperature above 875 degrees C., and suddenly cooling it to between 350 and 50 degrees C.; and then annealing the plate; substantially as described.

6. The method of making armor or ballistic steel plates, consisting in producing a steel plate containing vanadium, heating the plate to a temperature above 875 degrees C., and suddenly cooling it to between 350 degrees C. and 100 degrees C., and then annealing the plate; substantially as described.

7. The method of making armor or ballistic steel plates, consisting in producing a steel plate containing vanadium, heating the plate to a temperature above 875 degrees C., and suddenly cooling it to between 350 and 50 degrees C., and then annealing the plate by heating it to a temperature above 675 degrees C.; substantially as described.

8. The method of making armor or ballistic steel plates, consisting in producing a steel plate containing vanadium, heating the plate to a temperature above 875 degrees C., suddenly cooling it to between 350 and 50 degrees C., and then annealing the plate by heating it to a temperature above 675 degrees C. and below 725 degrees C.; substantially as described.

9. The method of making armor or ballistic steel plates, consisting in producing a steel plate containing vanadium, heating the plate to a temperature above 875 degrees C., and suddenly cooling it to between 350 and 50 degrees C., then annealing the plate and finally water-hardening it by raising its face to a temperature of about 900 degrees, and suddenly cooling said face; substantially as described.

In testimony whereof I have hereunto set my hand.

S. S. WALES.

Witnesses:

JOHN MILLER,
H. M. CORWIN.