UNITED STATES PATENT OFFICE.

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BALLISTIC PLATE.

No. 921,924. **Specification of Letters Patent.** **Patented May 18, 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 Improvement in Ballistic Plates, of which the following is a full, clear, and exact description.

My invention relates to ballistic plates, either with or without a carburized face.

The object of the invention is to provide a new alloy which will give a plate of higher ballistic resistance than those produced by the use of alloys and treatments now in use.

Another object of the invention is to increase the holding resistance of the body of the plate by preventing the destroying of the fibrous character of the body through a layer between the back proper and the super-carburized face, which is now present in face-hardened armor plate.

The alloy now commonly used in the manufacture of armor plates contains carbon, manganese, nickel and chromium. In protective deck plates the same is used with the omission of the chromium. Vanadium has also been used in commercial steels, such as tool steels, &c.; but to my knowledge vanadium has never been used with both nickel and chromium in ballistic plates. I have found that these three elements when used in ballistic plates, especially in conjunction with certain heat treatment which I have discovered, will greatly increase the ballistic resistance of steel plates, and produce certain other advantages.

In carrying out my process for the manufacture of either face-hardened armor plate, or protective deck plate, I use an alloy containing 2½ to 5 per cent. of nickel, 1 to 2 per cent. of chromium, and below 1 per cent. of vanadium. I have found the following to be best suited for the purpose, although other elements may be added to those specified, or the proportions may be varied within certain limits:—

Carbon	.20 to .35 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 re-carburizing 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.

If a face-hardened plate is to be made of considerable thickness, the ingot may be cast and preferably forged at the ordinary forging temperature. If it is to be reforged 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. If the entire process is carried out continuously, the plate may be reforged while hot and without allowing it to cool, and then given a temporary water-hardening before allowing it to cool and reheating. It may then be scaled and carburized in the ordinary manner if it is to be used for armor plate. It may then be reforged at the usual reforging temperature, and is then heated to a temperature of 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 reforged, the heating to 900 degrees C. and the quenching will immediately follow the forging; the plate not being allowed to become cold in the mean time. A further toughness may be imparted to the plate if desired by repeating these steps of heating to about 900 degrees and quenching. The steel is then raised to a temperature of 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 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 the difference in temperature need not be as great as is necessary in the ordinary standard nickel-chromium alloy now generally employed.

If the plate is not to be face-hardened, but is to be a protective deck plate or similar plate of thickness say under three inches, then in such case I proceed as follows:—

Having cast the ingot, it may be forged or rolled to the desired thickness. It is then raised to a temperature of about 700 degrees C. and cooled slowly, preferably in air. After it is cold, it is then heated to about 900 degrees C. and quenched with water until it is either at the temperature of the atmosphere or at a temperature not over 400 degrees C. I then preferably anneal the plate by raising it to a temperature above 450 degrees C. and below 700 degrees C., depending upon the purpose for which the plate is to be used; and cool the same slowly, preferably in air. The lower the temperature of the last or third heat treatment, the harder and less ductile the material will be.

By taking the plate after the third treatment and again raising it to about 900 degrees C., water-quenching it, and re-annealing it, the plate may be further toughened. By simply repeating the third heat treatment, or annealing step, the plate may be rendered more ductile.

The advantages of my invention result from the use of the three elements, nickel, chromium, and vanadium in an armor or ballistic plate.

I have discovered that while nickel intensified by vanadium is detrimental to the quality of steel subjected to vibratory stresses or strains, such as in crank shafts, connecting rods, &c., yet when chromium is combined with nickel and vanadium in ballistic plates, the resistance to intense sudden shocks such as met with in ballistic plates is considerably increased. This discovery I believe to be new, and wish to cover the same broadly no matter what heat treatments are employed, although the above heat treatments considerably enhance the value of the ballistic plates. One of the advantages obtained by this alloy is that where fibrous character is imparted by heat treatment, such character is much harder to destroy by subsequent treatments than heretofore with the alloys previously used. With the ordinary nickel chromium alloy this fibrous character of the plate is destroyed by subsequent treatments involving a temperature of 775 degrees C., or above. With my improved alloy, however, it has been found that the fibrous character is retained throughout the body of the plate in spite of heat treatments even rising above 900 degrees C.

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.

Many variations may be made in the proportions of the elements of the alloy, in the heat treatments, &c., without departing from my invention.

I claim:—

1. As a new article of manufacture, a ballistic armor or vault steel plate, composed of an alloy of iron with from .20 to .35 per cent. of carbon; .25 to .35 per cent. manganese; 3.5 to 4 per cent. nickel; 1.25 to 1.75 per cent. chromium, and less than one per cent. of vanadium; substantially as described.

2. As a new article of manufacture, a ballistic armor, or vault steel plate containing nickel below 3.75 per cent. and below one per cent. of vanadium, substantially as described.

3. As a new article of manufacture, a ballistic, armor, or vault steel plate containing nickel, chromium below two per cent. and below one per cent. of vanadium, substantially as described.

4. As a new article of manufacture, a ballistic armor or vault steel plate containing two and one-half per cent. to five per cent. of nickel, one per cent. to two per cent. of chromium and below one per cent. of vanadium, substantially as described.

In testimony whereof, I have hereunto set my hand.

S. S. WALES.

Witnesses:
JOHN MILLER,
H. M. CORWIN.