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PROCESS OF MANUFACTURE OF ARMOR PLATE.

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To all whom it may concern:

Be it known that we, JOHN B. JOHNSON and SAMUEL DANIELS, citizens of the United States, residing at Dayton, in the county of Montgomery and State of Ohio, have invented certain new and useful Improvements in Processes for the Manufacture of Armor Plate, of which the following is a specification.

This invention relates to an improved process for the manufacture of carburized armor plate for aircraft, tanks, or like purposes from any low carbon alloy steel or from straight low carbon steel. According to this invention, the steel ingot is mechanically worked by forging or rolling with such annealing as is necessary, to some thickness of plate greater than that desired in the finished plate, which greater thickness of plate is carburized to such a total depth of case that when this oversize carburized plate is rolled to size, the resulting total depth of case will be less than the required final total depth of case. The plate so treated may or may not be subjected to a heat treatment adequate to insure a fibrous structure of the uncarburized structure at this stage, but after rolling to size it is again carburized to the additional depth, which final total depth of case will bear a definite relationship to the total thickness of armor plate. Further, armor plate so carburized, or armor plate carburized by any other method so that the total depth of case bears the aforesaid relationship to the total thickness of plate, is cooled to atmospheric temperature and subsequently subjected to additional thermal treatment.

This improved process was applied as follows to armor plate 0.255 inch in thickness, made of a low carbon, high chrome-nickel steel of this composition:

Carbon	0.21
Phosphorous	0.010
Sulphur	0.017
Manganese	0.34
Nickel	3.91
Chromium	1.06

From the ingot was rolled plate approximately ½ inch thick. This plate was carburized at a temperature of 1700° F. To limit the carburization to one side only of each plate, every two plates were put together with a layer of fire clay and asbestos between.

After case hardening, the plates were rolled at a temperature of approximately 1750° F. to a thickness of about 0.255 inch of which the thickness of case was 0.021 inch. Of this total thickness of plate, about 0.020 inch was further carburized, and this on the same side as that which was initially curburized. The air cooled armor plate was then re-heated to 1450° F. and quenched in oil.

The treatment recommended for a plate rolled to the final thickness after an initial carburization is as follows:

1. Protect uncarburized side of plate.
2. Carburize the plate for from nine to twelve hours at a temperature of 1560° F.
3. Cool plates in carburizing box.
4. Re-heat to a temperature of 1450° F. and quench in oil.

Such armor plate, 0.255 inch thick, twelve inches square, set in the rabbets of horizontal and vertical wooden members, and bolted in behind additional wooden members, according to the specifications of the Navy Department, Bureau of Ordnance, the Ordnance Department, and the Air Service, U. S. A., withstood, at a distance of 125 feet, .30 calibre, 150 grain, armor-piercing ammunition, striking with velocities up to 2,247 feet per second.

Light armor plate of the thickness above specified, of any steel, treated by any methods other than those enumerated in this description, has not consistently withstood under the same conditions of test this same type of ammunition striking with velocity much over 1700 feet per second.

It may be desirable to roll the armor plate to its final thickness prior to case hardening and in such instance, armor plate 0.255 inch thick, of the composition mentioned above, has after all rolling been carburized to a depth of 0.040 inch at a temperature of 1560° F. and either slowly or rapidly quenched from the carburizing temperature. In this process the plate may be further carburized on the same side or, it may be further carburized on the same side and at the same time carburized on the hitherto uncarburized side to any desired extent. By carburizing in two or more stages, greater control over the quality, amount or proportion of carburization is

obtained. Subsequent thermal treatment involving re-heating to 1560° F. and quenching in oil, reheating to 1450° F. and quenching in oil or to 1400° F. and quenching in water; or, after cooling from the carburization process, the simple re-heating to 1450° F. and quenching in oil, or to 1400° F. and quenching in water, will also produce a light armor plate of the exceptional qualities described in the preceding paragraphs.

Should it be necessary to carburize the plate to different depths on opposite sides, the process may be carried out in either of two ways. First, the plate of an oversize depth may be carburized to a desired depth on one side alone and rolled to the final thickness; the plate is then protected against further carburization on its carburized side and the carburization treatment applied on the uncarburized side until the required depth of carburization is reached (as shown by "test scrap" from the plate), whereupon it may be treated thermally as desired. The second method may be used when the plate is initially of the desired thickness, in which case the plate will be carburized, one side at a time, and to the desired depth, protecting the opposite side from carburization, thereafter applying appropriate thermal treatment.

What we claim is:

1. The method of producing armor plate which consists in carburizing one surface of said plate in successive stages alternated with mechanical working of the plate.

2. The method of producing armor plate which consists in carburizing an oversize plate, rolling said plate to final thickness and further carburizing said plate.

3. The method of producing armor plate which consists in carburizing an oversize plate for a predetermined period, rolling said plate to final thickness, further carburizing said plate and thermally treating to restore and insure fibrous structure of the uncarburized portion.

4. The method of producing light armor plate which consists in carburizing an overthickness plate for a predetermined period, thermally treating said plate, rolling said plate to its final thickness and further carburizing said plate.

5. The herein described process of manufacturing armor plate consisting in subjecting the plate, before it has reached its final thickness, to a carburizing operation, then rolling the carburized plate to the required final thickness, then further carburizing the plate to form a depth of case from ten to forty-five per cent of the total thickness of the finished plate, depending on the ballistic resistance required, then heating the plate to approximately 1560° F., then quenching in oil, then reheating the plate to 1400° F., and finally quenching in oil.

6. The herein described process of manufacturing armor plate consisting in subjecting the plate, before it has reached its final thickness, to a carburizing operation, then rolling the carburized plate to the required final thickness, then further carburizing the plate to form a depth of case from ten to forty-five per cent of the total thickness of the finished plate, depending on the ballistic resistance required, then heating the plate to approximately 1560° F., then quenching in oil, then reheating the plate to 1400° F., and finally quenching in water.

7. The herein described process of manufacturing armor plate consisting in subjecting the plate before it has reached its final thickness, to a carburizing operation, then rolling the carburized plate to the required final thickness, then further carburizing the plate, on one side only while protecting the other side, to form a depth of case from ten to forty-five per cent of the total thickness of the finished plate, depending on the ballistic resistance required, then heating the plate to approximately 1560° F., then quenching in oil, then reheating the plate to 1450° F., and finally quenching in oil.

8. The herein described process of manufacturing armor plate consisting in subjecting the plate before it has reached its final thickness, to a carburizing operation, then rolling the carburized plate to the required final thickness, then further carburizing the plate, on one side only while protecting the other side, to form a depth of case from ten to forty-five per cent of the total thickness of the finished plate, depending on the ballistic resistance required, then heating the plate to approximately 1560° F., then quenching in oil, then reheating the plate to 1400° F., and finally quenching in water.

9. The process of manufacturing armor plate which consists in subjecting the plate, before it has reached its final thickness, to a carburizing operation so conducted that after the rolling operation which reduces the plate to the final thickness, the total depth of the case will be from ten to forty-five per cent of the total thickness of the finished plate, subsequently reheating the plate to 1450° F, and then quenching in liquid.

In testimony whereof we have affixed our signatures.

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