

UNITED STATES PATENT OFFICE.

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MANUFACTURE OF CEMENTED ARMOR-PLATES AND OTHER ARTICLES OF STEEL OR
ALLOYS OF STEEL.

991,972.

Specification of Letters Patent.

Patented May 9, 1911.

No Drawing.

Application filed August 31, 1908. Serial No. 451,051.

To all whom it may concern:

Be it known that I, FEDERICO GIOLITTI, a subject of the King of Italy, and residing at No. 35 Via Palestro, Rome, Italy, professor of chemistry, have invented certain new and useful Improvements in the Manufacture of Cemented Armor-Plates and other Articles of Steel or Alloys of Steel, of which the following is a specification.

10 This invention consists in improvements in the manufacture of cemented armor plates of steel and alloys of steel (hereinafter included in the term "steel") for ships and other uses.

15 The methods employed hitherto for introducing carbon into a mass of steel or iron by diffusion without melting the metal (which method is designated by the generic name of "cementation") may be divided into two distinct types.

20 The first type consists in heating the iron or steel article to be cemented, to a suitable temperature (usually in the neighborhood of the melting point of cast iron) and in pressing against one or more surfaces of the said article a mixture of solid substances (such as various organic substances or cyanids, ferrocyanids, etc.), in the powdered or granular form containing carbon in the free state or in the state of unstable combination.

25 The second type consists in heating the steel or iron article to a high temperature, without melting it, in an atmosphere of various carburized gases such as saturated and non-saturated gaseous carbids of hydrogen; vapors of volatile carbids of hydrogen, with or without an admixture of nitrogenous substances, etc.

30 In the methods of the second type (cementation by means of gas) employed hitherto, the influence of temperature on the speed of diffusion and penetration of the carbon in the mass of solid metal is taken into consideration, and certain limiting temperatures have been determined between which the diffusion takes place most rapidly. Those methods however do not simultaneously take into consideration another very important factor, namely the pressure of the carburizing gas.

Now the improved process forming the subject of the present invention is based on

the employment of determined pressures of the carburizing gas relatively to the temperature at which the cementation takes place and to the chemical nature of the gases or vapors employed in the cementation process.

The improved process consists substantially in heating the article to be cemented, in a gaseous carburizing medium under a relatively high pressure at a relatively high temperature.

By suitably selecting pressures relatively to the temperature of cementation and the chemical nature of the gases or vapors employed in the cementation process (and also relatively to the nature of the solid carburizing substances which may be employed with the gases and vapors), the duration of the cementation process can be considerably shortened, or a deeper penetration of the carbon can be obtained in the same time.

Generally the speed of the penetration of the carbon into a mass of iron or steel, or what is equivalent thereto, the depth to which the carbon penetrates during a determined length of time into the mass, increases considerably with an increase in the pressure of the carburizing gas, provided that the increase in pressure is accompanied by a suitable variation of the temperature at which the cementation process takes place. This is effected by raising the temperature when the reaction of the decomposition of the carburizing gas (when the gas gives up carbon to the steel) is endothermic, and by lowering the temperature when the reaction is exothermic. All this applies to cases in which the decomposition of the carburizing gas or vapor takes place with a diminution of volume.

In cases in which the decomposition is attended by an increase of volume, all the above relations must be reversed.

In general, a very great advantage will be obtained by effecting the cementation in an atmosphere of carburizing gases or vapors under a higher or lower pressure according to the nature of the said gases or vapors, provided that the temperature is varied at the same time in accordance with the above stated rules.

The following example is given with the object of illustrating the manner of performing this invention. It is assumed that

it is desired to "cement" by means of carbon monoxid a mild steel of approximately the following composition:—

5	Carbon-----	0.1 to 0.2 per cent.
	Manganese-----	0.2 " 0.4 " "
	Phosphorus-----	0.02 " 0.04 " "
	Silicon-----	traces.
	Sulfur-----	traces.

- 10 Now the reaction expressed by the equation $2\text{CO}=\text{CO}_2+\text{C}$ according to which the carbon monoxid can give up one half of its carbon to the steel, is endothermic, and it is attended by a diminution in the volume of the gas. Therefore the "cementation" will be effected more quickly by increasing the pressure of the gas, provided that in accordance with the above stated rule, the temperature is raised at the same time. Consequently, while cementation with carbon monoxid at the ordinary pressure, is carried out with advantage at a temperature of from 950 to 1000 degrees C. if the process be carried out at a pressure of say, over four atmospheres, the temperature must be increased to about 1100 degrees C. Under these conditions of temperature and pressure it is easy to obtain in less than 12 hours, in a steel of the above specified composition, a highly carburized layer having a depth of 8 to 9 millimeters, whereas in operating at the ordinary pressure the depth of the highly carburized layer which is obtained during the same period of time does not exceed 2 to 3 millimeters. Then by alternately increasing and diminishing the pressure and temperature, successive layers may be produced having a greater or less degree of carburization.
- 40 As the intensity of the carburization increases with the increase of the temperature and pressure, and as the diffusion of the carbon toward the interior of the article to be cemented proceeds continuously every time that the temperature or the pressure is raised, this will produce on the outside of the article a more strongly carburized layer which then slowly diffuses toward the interior and may be followed by a less carburized layer, if the temperature or the pressure, or both, be lowered.

The advantages obtained by this invention may be classified under three heads, namely: First. The considerable shortening of the time necessary for effecting cementation to a given depth, which represents a great saving in time, labor, etc. Second. By remaining exposed to a high temperature during a much shorter period the steel is much less liable to undergo the deterioration of its physical and mechanical properties which always accompanies much thermal treatment and which must be corrected by subsequent treatment. Third. By suitably varying the pressure and the temperature according to

the above stated rule, it is possible to obtain zones of different degrees of carburization in the different successive layers.

The improved process produces still better results if the steel articles that are subjected to the action of carburizing gases and vapors under pressure (at a temperature determined in the manner above stated), be immersed totally or partially in a mixture of granulated or powdered carburizing substances (such as animal charcoal, vegetable charcoal, potassium ferrocyanid, cyanid, etc., employed separately or mixed together) capable of reacting or not reacting with the carburizing gas or vapor. These solid substances must be suitably pressed upon the articles to be "cemented", but so as to allow the gases to pass freely through the interstices of their mass. These substances, besides exercising their carburizing power which is either inherent in them, or arises from their reactions with the gases, have also the function of facilitating the transmission of heat to the masses of steel. Thus for instance, in the particular case hereinbefore described, the combination attains in a given time a maximum depth when the steel articles to be "cemented" are surrounded by a coarse powder composed of a mixture of 60 per cent. of vegetable charcoal and 40 per cent. of animal charcoal contained in the cementing box, in such a manner as to fill the space left unoccupied by the steel articles, but so as to allow the carbon monoxid under pressure to pass with adequate ease through the interstices of the powder.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:—

1. The improved process of cementation of armor plates or other articles of steel, which consists in heating the article in a gaseous carburizing medium at a temperature which is higher the more endothermic the cementing reaction, and under a relatively higher pressure which is higher the greater the diminution produced by said reaction in the volume of the gaseous medium, said temperature and pressure being directly dependent on each other, so that when the temperature is increased the pressure must also be increased, and vice versa.

2. The improved process of cementation of armor plates or other articles of steel, which consists in heating the steel article in the presence of a granular carboniferous material through which a current of carburizing gaseous medium is caused to circulate at a temperature which is higher the more endothermic the cementing reaction, and under a relatively high pressure which is higher the greater the diminution produced by said reaction in the volume of the gaseous medium, said temperature and pressure

being directly dependent on each other, so that when the temperature is increased the pressure must also be increased, and vice versa.

5 3. The improved process of cementation of armor plates or other articles of steel, which consists in heating the steel article in a current of gaseous carburizing medium under a pressure exceeding four atmospheres at a temperature of about 1100 degrees centi-
10 grade.

4. The improved process of cementation of armor plates or other articles of steel, which consists in heating the steel article

surrounded by a coarse powder composed of 15 a mixture of 60 per cent. of vegetable charcoal and 40 per cent. of animal charcoal in a current of carbon monoxid under a pressure exceeding four atmospheres at a temperature of about 1100 degrees centi- 20 grade.

In testimony whereof, I affix my signature in presence of two witnesses.

FEDERICO GIOLITTI.

Witnesses:

G. B. ZAMARDO,

G. BIZZARI.