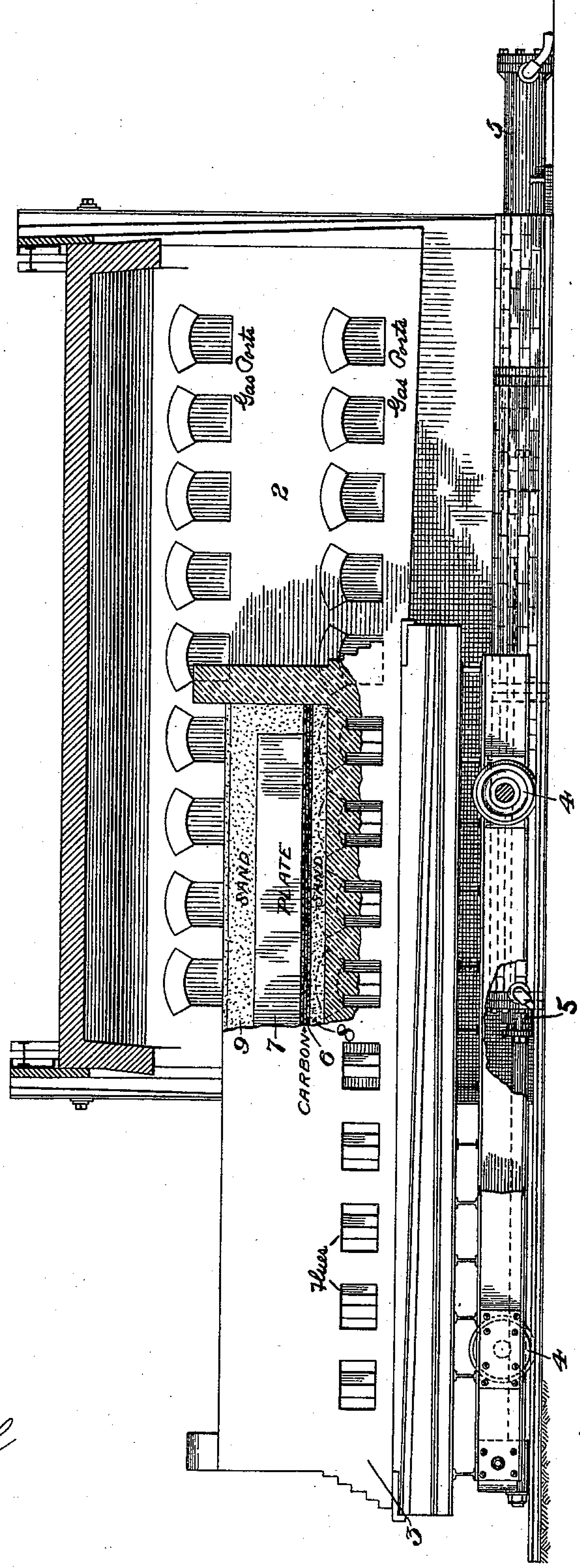
(No Model.)

W. E. COREY.

STEEL ARMOR PLATE AND PROCESS OF MAKING SAME.

No. 541,594. Patented June 25, 1895.



Witnesses
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UNITED STATES PATENT OFFICE.

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STEEL ARMOR-PLATE AND PROCESS OF MAKING SAME.

SPECIFICATION forming part of Letters Patent No. 541,594, dated June 25, 1895.

Application filed June 5, 1895. Serial No. 551,704. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM ELLIS COREY, of Munhall, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Steel Armor-Plates and Processes of Making the Same, of which the following is a full, clear, and exact description.

The accompanying drawing shows in side elevation, partly in longitudinal section, a furnace suitable for effecting the supercarbonization of the steel plates.

By use of my invention I produce steel having an unusual degree of toughness and strength, combined with extreme hardness, which is specially adapted to the manufacture of armor plates for vessels, and to other purposes for which the characteristics of great toughness and strength with extreme hardness are desired.

My invention lies in a new method of treating steel plates, which consists broadly in heating the plate, while one of its surfaces is in contact with a carbonaceous material, to such a temperature that the surface portion becomes supercarbonized, while the body of the plate is converted into a coarse crystalline and more brittle condition and then subjecting the plate to an extreme compression while at a temperature below 2000° Fahrenheit, and without producing more than a slight elongation, this compression being substantially uniform throughout the area of the plate.

It also consists in the product of said method.

In order to enable those skilled in the art to practice my invention, I will now describe my method as applied to the manufacture of armor plate, and similar large and thick bodies of steel.

Armor plates are usually of an average size of sixteen feet in length, eight feet in width, and from fourteen to eighteen inches in thickness, and supercarbonized or hardened on one side or surface only; the hardening effect in such case gradually decreasing from the supercarbonized surface toward the other side, as the necessary result of applying the carbon to one side only. My invention, however, applies to plates, slabs or ingots of steel hardened on both or all sides. I have stated the dimensions for the reason that in describing the process, so as to be intelligible to others skilled in the art, it is desirable to indicate the size of the articles to the treatment of which the temperatures and length of time used in the several steps are applicable; these features of my process being necessarily subject to modification, as the larger the size of the piece of steel under treatment the greater will be the heat, and to some extent the time of exposure thereto, which will produce the best results.

By the term "steel plate" as used in this specification, I mean plates made by any process of conversion of iron into steel, and whether the steel be or be not alloyed or mixed with nickel, aluminum, or other metal or alloy.

The plate, having been made of steel of the desired quality, cast into ingots and forged or rolled to the desired thickness and surface shape, is placed in the supercarbonizing furnace, in a receptacle or hearth of refractory material which may be removable to and from the furnace. The bottom of this receptacle is covered with a layer of comminuted carbonaceous material being of uniform thickness, preferably laid upon a layer of sand, and so placed as to be in close contact with the surface of the steel plate to be treated, which may be of plane, or curved, or irregular shape. The carbonaceous material used for this purpose may be such as animal or vegetable charcoal or coke or a mixture of any or all of these.

The advantage of placing the steel plate on top of the carbon is that the plate and carbon are thus brought into close surface contact, and when two or more plates are to be treated, they should be placed one above the other with the steel surfaces to be supercarbonized turned toward, and in contact with, the carbon, thus having one layer of carbon between two plates. If, as is usual in armor-plates, they are to be supercarbonized on one side only, the surface not requiring treatment is covered with some refractory material; or the access of the external air is otherwise excluded, so as to prevent the oxidation of the carbonaceous matter and of the steel.

The furnace containing the steel plates in the receptacle, as above stated, and used for heating the plates, may be a regenerative gas furnace, or one otherwise suitable. The furnace is heated to a comparatively low heat, say about 1950° Fahrenheit and the temperature is gradually raised, during a period of about ten days, until the steel is heated up to about 2175° Fahrenheit. The gas is then shut off and the furnace is banked for about a week's time, during which a gradual cooling takes place, until the plates are reduced in temperature to about 1600° Fahrenheit.

A furnace of suitable form for effecting the supercarbonizing of the steel plate is shown in the drawing, in which 2 is the heating chamber, and 3 a movable hearth or receptacle carried by a truck mounted upon wheels 4, and adapted to be moved into and from the furnace by a motor cylinder 5.

6 is the layer of carbon beneath the armor plate 7.

8 is the sand layer under the carbon, and 9 is a protecting covering of sand.

The result of subjecting the plate to the above treatment is to change the semi-fibrous character of the body of the plate produced by the previous working and convert it into a coarse crystalline condition, thus impairing the main mass while hardening its surface. This weakened condition of the plate, which has heretofore been inherent in supercarbonized steel plates, is entirely removed by the next step of my process, which consists in compressing and compacting the plate at a low heat. This compressing operation not only restores to the metal its forged character, but also adds increased strength, density and toughness by reason of the low heat employed therein. As, however, it is important to ascertain the condition of the steel plates as to the degree of carbonization and the depth to which it has extended, it is preferable to postpone the compression of the plates until they have been tested. In this case they are allowed to remain in the furnace until reduced in temperature to about 1100° Fahrenheit so as to avoid air-hardening, which might occur at a higher temperature, and also to aid in annealing. When thus reduced in temperature the plates are removed from the furnace and receptacle in which they were heated and are allowed to cool gradually in the air to a suitable heat, say 100° Fahrenheit, when the faces which have been covered with refractory material are cleaned off with brushes or otherwise, and a few holes are drilled in each plate from the supercarbonized surface, and samples of the drilling at different depths are taken and analyzed to ascertain the depth and degree of carbonization. These plates, if they have been cooled for the purpose of testing, have to be reheated sufficiently for compression, up to about 1600° Fahrenheit, which reheating is, of course, not necessary when the plates are removed from the furnace at that temperature. Before replacing the plates in the furnace to reheat them sufficiently for compression, I cover the carbonized surface or surfaces with a coating of about three inches of pulverized carbonaceous matter, which may be protected in some suitable manner to guard against oxidation of the carbon or of the surface of the steel.

I have stated the degree of heat at which the plates are to be removed from the furnace for compression, or to which they are to be reheated for that purpose, to be about 1600° Fahrenheit, the purpose being to have the plates at as low a heat as will enable them to be compressed as hereinafter described; but the heat should not exceed 2000° Fahrenheit, the temperature required being a heat sufficiently high to permit the metal to be compressed, but below that proper for ordinary elongation and reduction of the metal in rolling. This reheating should be done slowly, so as to secure an even heat throughout the plate, and should take from ten to twenty hours, according to the size of the plate. The plate is then taken to the compressing machine,—a hydraulic press or a hammer adapted to impart a strong compression to the metal and to compact it throughout. I have found that the use of rolls is not desirable, as the metal will elongate and its body will not become compressed and condensed as when the press is employed. It is much preferable to use a hydraulic press, and I make the dies of the press (upper and lower) as long as the plate of steel is wide, and with comparatively narrow faces, say from ten to twelve inches. If the faces of the dies are too wide, the plate will have to be at a higher temperature, in order to secure the desired degree of compression; and a temperature as low as is compatible with that result is desired, as already stated, in order to prevent decarbonization of the plate, and also to secure the condensing and compacting effect of the pressure applied, instead of a spreading or elongating of the steel, which would be the consequence if the metal was too hot.

When a hydraulic press is used which is capable of exerting a pressure of about ten and a half tons to the square inch of surface, an armor plate, of the dimensions before stated may be readily reduced an inch in thickness by each first stroke of the upper compressing die. The plate is moved forward between the dies after each stroke until the entire surface has been acted on. This operation is repeated, moving the plate back and forth, until sufficient compression is secured. By this means I have succeeded in reducing a plate of seventeen inches thick to a thickness of fourteen inches, with the effect of giving greatly increased toughness and strength to the steel. As the object is not to roll out the plate, and thus increase its length or width, but to effect an actual compression of the metal (although some increase in those dimensions will occur, as the plate need not be confined in any way), it is obviously desirable to subject the metal to great pressure at as low a temperature as is compatible with the actual compression of the plate. In practice I find that when I thus compress a nickel steel armor-plate sixteen feet long, eight feet wide and seventeen inches thick, with a hydraulic press capable of exerting a compression of about ten tons per square inch, so as to reduce the plate to a thickness of fourteen inches, the plate elongates only about thirty inches more or less, and does not perceptibly expand laterally. After the plate has thus been toughened and compacted by pressure, it is annealed. For this purpose, it is reheated in the furnace during a period of about twelve hours, up to about 1350° Fahrenheit. The heat is then withdrawn, the plate remaining in the furnace for about forty-eight hours while slowly cooling.

During the reheating for annealing the supercarbonized portion of the plate is protected from oxidation by a light covering of carbonaceous matter, which may be protected by some suitable refractory substance, as before described.

When sufficiently cool after annealing and before tempering, the plate may, if desired, be again tested to ascertain whether it is sufficiently carbonized, and it is straightened by a forging press, or otherwise, and is machined to the required dimensions, the necessary allowance being made for contraction during the subsequent tempering, which is the last step of the process. In order to do this, the plate is again slowly heated in the furnace to about 1350° Fahrenheit, the precautions before employed to prevent oxidation of the surface being repeated, and any scale or other matter adhering to the carbonized surface of the plate is carefully removed, before and after reheating, by wire brooms, or if necessary by hand hammering. The reheated plate is hardened by means of cold water, which may be conveniently applied to the plate in a horizontal position on an open frame work, between a series of nozzles above and below the plate, which spray copious jets of cold water on the plate. This is continued until the plate is sufficiently cold, say at a temperature of 100° Fahrenheit. This completes the operation, excepting that if the plate has become misshapen by the water cooling it is reheated to a low temperature, say 200° Fahrenheit, sufficient to permit of its being rectified in shape by the hydraulic press or otherwise, and that it has to be machined or ground by an emery wheel to the exact size required.

In describing my operation I have thought it necessary to state the degrees of temperatures which I have found it advisable to use in the various steps of my process; but I do not desire to confine myself to the exact temperatures described. I deem it important, however, to conduct the various steps of my process in which heat is applied, at as low a degree of heat as is consistent with successful operation, and especially is this the case when the steel is being compressed, as the object is to produce homogeneous compression or compression throughout the entire mass, and to as great a degree as possible, so that the heat should be as low as will permit of the actual compression and compacting of the steel. I also desire to have it understood that it may not be necessary in all cases to observe the exact order of operation, or to perform all the steps described, as, for example, it is not necessary to allow the steel plates to cool and then to reheat them before subjecting them to compression, although, as before stated, it is desirable previously to test the carbonization of the plates, for which purpose they should be cold enough to handle, and would then require reheating.

In this specification I have referred to the protecting of the plates, while being reheated, with a coating of carbonaceous matter, and a superimposed layer of finely comminuted refractory substance. This is specially important where nickel steel, (by which I mean steel to which nickel in any proportion has been added) is being treated for carbonization, or in any case where nickel steel requires to be subjected to heat owing to the excessive scaling, or surface oxidation to which nickel steel is subject. In order to obviate this, I carefully remove any scabs or loose scale from the nickel-steel before reheating it, and cover its carbonized surface with a layer of from two to four inches in thickness of dry carbonaceous matter of any description, such, for example, as coke dust or charcoal, and protect this carbonaceous matter from oxidation in any suitable manner.

In reciting in my claims the first or supercarbonizing step of my process, I wish to be understood as covering not only the specific step recited above in my specification, but also any step of supercarbonizing wherein the metal is heated and exposed to carbon in any form such as the well known method by the use of gas which is passed over the heated plate.

The advantages of my invention are apparent, since the metal which has been impaired by the supercarbonizing step is not only restored to its former texture, but is condensed and its strength materially increased, thus combining the advantages of a plate having a carbonized face with those of a non-carbonized but forged plate having the stronger character peculiar to forged metal.

The characteristics of the steel plates treated as described above, which constitute an improved article of manufacture, and by which they may be distinguished from plates treated by heretofore known processes, are an extremely hard face of condensed steel, with a higher degree of carbonization at the surface than in the interior, showing on fracture a texture approaching the fibrous as distinguished from crystalline; the grain of the metal being fine as distinguished from the coarse grain appearance of cast steel, yielding a much higher ballistic test, say from twelve to fourteen per cent. higher, of a tensile strength of about twelve per cent. greater, an elongation of about fifteen per cent. greater, and a much greater resistance than plates made by processes known and used prior to my invention.

I claim—

1. The herein described method of treating a steel plate containing carbon, consisting in heating the plate, while one of its surfaces is in contact with a carbonaceous material, to such a temperature that the surface portion becomes supercarbonized while the body of the plate is converted into a coarse crystalline and more brittle condition, and then subjecting the plate to extreme compression while at a temperature sufficient for compression, but below that proper for the ordinary elongation and reduction of such steel by rolling, producing by such compression a compacting of the plate without more than a slight elongation, said compression being substantially uniform throughout the area of the plate, whereby the thickness of the supercarbonized surface portion as well as of the body of the plate is materially decreased and the structure of the steel is brought throughout into a fine grained, tough, dense condition.

2. The method of treating a steel plate consisting in supercarbonizing the surface portion of the plate and then subjecting it to a succession of step-by-step compressions each operating over a small portion only of the surface while at a temperature below 2000° Fahrenheit until the desired degree of reduction is attained, substantially as described.

3. The method hereinbefore described of producing compressed carbonized steel, consisting of carbonizing the plate, slab or other article of steel, by applying to the side or sides, surface or surfaces to be carbonized, comminuted carbonaceous matter, protected from oxidation by suitable covering; exposing the same to the heat of a furnace, and therein heating the same to effect carbonization, and afterward, when the plate is at a temperature sufficient for compression, but below that proper for the ordinary elongation and reduction of such steel by rolling, subjecting the plate, at the low heat indicated, to sufficient pressure to effect the compression of the metal without producing more than a slight elongation, and subsequently annealing and hardening the same, substantially in the manner and for the purpose described.

4. The process hereinbefore described of preparing hardened steel-plates for armor plate, consisting of the following steps:—carbonizing the plate previously formed to substantially the required shape, by covering the same, or the surface to be hardened, with comminuted carbonaceous matter placed in close surface contact with the plate, protecting from the access of air the carbonaceous matter as well as the portions of the plate not requiring carbonization, with refractory material, or in other suitable manner; placing the same in a suitable furnace, heated to about 1950° Fahrenheit, gradually raising the heat during a period of about ten days, until the steel is heated to about 2175° Fahrenheit, then gradually cooling down until the steel is reduced to about 1600° Fahrenheit, subjecting the plate, at that heat, or thereabout to forcible compression, thereby compacting the metal; then annealing the plate by reheating it, (the carbonized surface being protected from oxidation) and slow cooling; and, after straightening, testing and machining the plate to the exact shape required, hardening the plate by slowly reheating in a furnace to about 1350° Fahrenheit and then cooling by the application of cold, substantially as and for the purpose described.

5. As a new article of manufacture, an armor plate composed throughout of steel having an extremely hard face more highly carbonized than the interior of the plate, said face and body being in a highly compressed and compact condition and considerably denser than similar plates which have been shaped or reworked at the usual forging temperature and the body being composed of non-crystalline steel of a forged or semifibrous nature, showing in fracture throughout its mass a fine grained dense condition in contra-distinction to the coarse crystalline appearance of cast steel, and giving a much higher ballistic test than ordinary non-compressed supercarbonized or surface hardened steel of the same dimensions; substantially as described.

In testimony whereof I have hereunto set my hand, June 4, 1895.

WILLIAM ELLIS COREY.

Witnesses:

H. M. CORWIN,

C. BYRNES.