UNITED STATES PATENT OFFICE.

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PROCESS OF TREATING MALLEABLE IRON.

SPECIFICATION forming part of Letters Patent No. 504,841, dated September 12, 1893.

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To all whom it may concern:

Be it known that I, JOHN H. LADD, a subject of the Queen of Great Britain, residing at London, England, have invented a new and useful Improvement in Processes of Treating Malleable Iron, of which the following is a specification.

My invention relates to an improvement in processes of treating iron, and has particular relation to the treatment of iron which has been previously decarburized or which contains not more than five-tenths of one per cent. of carbon and is of the kind classified as malleable iron.

The term "wrought iron" herein employed is intended to describe iron which is substantially free from carbon, that is to say, the kind of iron generally described in the art by this term.

The purpose of my invention is to improve the quality of such iron when in a fibrous condition, in a manner somewhat similar to the process known as cementation; and my object is further to convert such iron into a fibrous condition when the same shall have become crystallized from any cause; and my object is further to accomplish the purposes here stated in an economic manner, both as to time and as to cost.

My invention is based upon the discovery made by me that if iron, which has assumed a crystalline character and which is sufficiently low in carbon, is subjected to the action of a pure gaseous vapor, by which is meant a gaseous vapor containing hydrogen, oxygen, nitrogen and carbon in proper combination and in proper relative proportion to furnish a high temperature when burned, having combined with it a small percentage of vapor of water and containing no sulphur or other deleterious agent, the iron will be changed to a fibrous condition and any sulphur or phosphorus that may be contained in the iron, or an appreciable percentage thereof, will be removed if the exposure to the heat be continued for a sufficient length of time. A further discovery which forms a basis for this invention lies in the fact that the cementation of fibrous malleable iron, by which is meant the introduction therein of carbon for its conversion into a steely iron, may be accomplished very successfully and with greater uniformity, and without danger of causing deterioration, if a gaseous vapor having combined therewith a small percentage of vapor of water be utilized to furnish the carbonaceous flame with or without the addition of a further quantity of carbon combined with the vapor, or in a separate combination, and substantially free from sulphur or its compounds, which are thus not reintroduced during the process.

Heretofore the possibility of returning crystallized malleable iron to the fibrous condition by frequent reheating and forging has been recognized to a greater or less extent, and the eventual product is found to be sufficiently satisfactory so far as the fibrous characteristic is concerned, but the product is much reduced in strength as compared with other wrought iron. This deterioration is sometimes ascribed to the presence of impurities from the furnace, the most prominent and objectionable of which is sulphur in one or another of its forms. As compared with such a process the process which I follow for the same end produces a result not only more rapidly, requiring but a single heating for a period ordinarily not exceeding one to two hours, and even as low as forty minutes, without subsequent forging for the purpose, but a result superior in the matter of quality and uniformity. The gas composed essentially of the ingredients above outlined, which may be produced in a manner hereinafter described, or any other satisfactory way, being itself substantially free from sulphur, and burning with a temperature sufficiently high to maintain the iron continuously during the period of treatment at a white heat without melting, with or without subsequent rolling or hammering causes the conversion of the crystallized to fibrous iron and removes sulphur. As a result the iron converted by this process presents a closer long fiber and a greater tensile and transverse strength than iron previously having the same crystallized character and converted with a coal furnace, or one employing an ordinary hydrocarbon gas alone.

A convenient and desirable mode of producing such gas as is herein described is the following: Atmospheric air at a normal temperature is caused to become charged with a

small percentage of hydrocarbon (benzine) by bringing it into contact with the vapor of a liquid hydrocarbon (benzine), and the carbureted air thus obtained is thereupon caused to be charged to a sufficient extent with the vapor of water. A fair analysis will show about 3.395 grains of vapor of water in forty-five grains of vapor of benzine to the cubic foot of combined gas. This gas, when burned, gives a very high temperature. As will be seen, carbon in a comparatively small proportion is combined with oxygen, nitrogen and hydrogen, and the compound is practically, if not absolutely, free from sulphur and other deleterious agents, and contains an additional percentage of vapor of water, heretofore, it is understood, believed to be detrimental, by itself to the treatment of iron.

In the practice of the process to which this invention relates for converting crystallized into fibrous iron, as well as the process presently referred to for accomplishing the cementation of iron, whether crystallized or not, as well as the further manipulation by which scrap iron of a more or less crystallized character is converted into a fibrous product, it is believed that the vapor of water when combined in the manner described with a hydrocarbon and atmospheric air exerts an important effect. A comparison of results with and without the use of the vapor of water, shows an increase of utility approximating twenty-five per cent. or upward when the vapor of water is employed. The carbon contained also, as before produces a material of special effect in the treatment of the iron aside from contributing its function in the matter of combustion. Whether the iron be crystallized or fibrous, if it be introduced into a furnace and subjected entirely to the heat of the gaseous compound above described, together with the introduction of highly carbureted air at about the final period of its maintenance in the furnace, and before the iron reaches the welding point the result is found to be a uniform cementation of the wrought iron into steel. The same process is employed for further carbonizing steel, without remelting, thus hardening the product.

I am aware that the cementation of wrought iron in charcoal has been practiced; and I am also aware that wrought iron has been subjected to the action of a hydrocarbon flame produced in the ordinary way for the same purpose; but in the first of these processes the introduction of deleterious agents has been unavoidable, and with the second not only has deterioration been produced, though perhaps to a less extent, but the heat obtained from the combustion of an ordinary hydrocarbon has been too slight to accomplish a material change in a short time, and entirely insufficient to accomplish the best results under the most favorable conditions.

As the amount of carbon to be introduced is, under ordinary circumstances, very small, and may be merely a fraction of one per cent., the conveying power of the gaseous fluid is found sufficient for the introduction of the extra amount of carbon by my process; but if it is found insufficient at a normal pressure I find it advisable to increase the pressure to such a degree as will enable the proper amount of carbon to be introduced.

The making of wrought scrap into blooms involves a procedure substantially identical with the process of converting crystallized into fibrous iron above described, and particularly so if the wrought scrap be more or less crystallized. The piles introduced into the furnace in the usual manner are subjected to a welding heat produced with the gaseous compound and having the essential ingredients above named to wit, air, hydro-carbon vapor and vapor of water, in about the proportions named.

The operation, so far as I have been able to observe it, is to remove from the iron those agents which prevent welding and permit the return of the continuity of the fiber under the operation of rolling or hammering. By introducing into the iron, while in the furnace at a welding temperature, with or without abnormal pressure, carbureted air, or merely carbonic oxide surcharged with carbon or not, as may be determined, the product may be caused to attain a steely property not heretofore found possible even under the most favorable conditions with a coal or simple hydro-carbon furnace.

In demonstration of the improved character of the product made by the foregoing procedures, the following may be given: A test bar made from iron manufactured into a bloom in a coal furnace showed a tensile strength of forty-eight thousand one hundred and twenty-seven pounds. A similar test bar made under similar conditions but employing the heat obtained with the gaseous compound, above described, showed a tensile strength of fifty-one thousand one hundred and forty-six pounds. Car axles were made from ordinary scrap in a coal furnace of the best known pattern, forged into slabs and re-heated for forging into axles, and three axles were also made from similar material treated entirely with the gas having the above characteristics, and the lateral strength tested. The gas made axles withstood a pressure equivalent to from five to seven twenty foot drops of a sixteen hundred and forty pound hammer more than the coal made axles, and the fracture showed an essentially tough fibrous character, while the coal made axle showed a distinctly crystalline fracture. The same difference in the character of the metal is discovered if after treatment of the bar for from say forty minutes to one hour under the heat obtained from this gas, with or without the introduction before the conclusion of the operation of an additional quantity of carbon, it is fractured for purpose of examination. The fiber is steely in appearance and color, and the product thus made from com-

mon crystallized scrap bears a close resemblance to the best Swedish iron.

What I claim as new, and desire to secure by Letters Patent, is—

1. The process of treating crystallized wrought iron substantially free from carbon to change the same to a fibrous condition, which consists in subjecting the iron to the action of a gaseous composition consisting of air, hydrocarbon vapor and vapor of water, substantially of the nature described, in a state of combustion, whereby the molecules assume throughout a fibrous structure, and the product is otherwise improved, as set forth.

2. The process of treating malleable iron for the purpose described, which consists in subjecting it to the action of a gaseous composition of air, hydrocarbon vapor and vapor of water in combustion, to heat the iron to a welding point without melting its mass, and before removing the iron from the heat increasing the proportion of carbon contained in the gaseous composition acting upon the iron, substantially as described.

3. The process of treating iron which consists in piling the crystallized metal and subjecting the same to the action of a gaseous composition in a state of combustion, composed of air, hydrocarbon (benzine) vapor and vapor of water in about the proportions named and free from sulphur, maintaining the iron at the welding heat obtained from said gaseous composition, and before removing the iron therefrom increasing the carbon constituent of said gaseous composition, without introducing sulphur, substantially in the manner and for the purpose described.

JOHN H. LADD.

In presence of—
DOUGLAS DYRENFORTH,
M. J. FROST.