

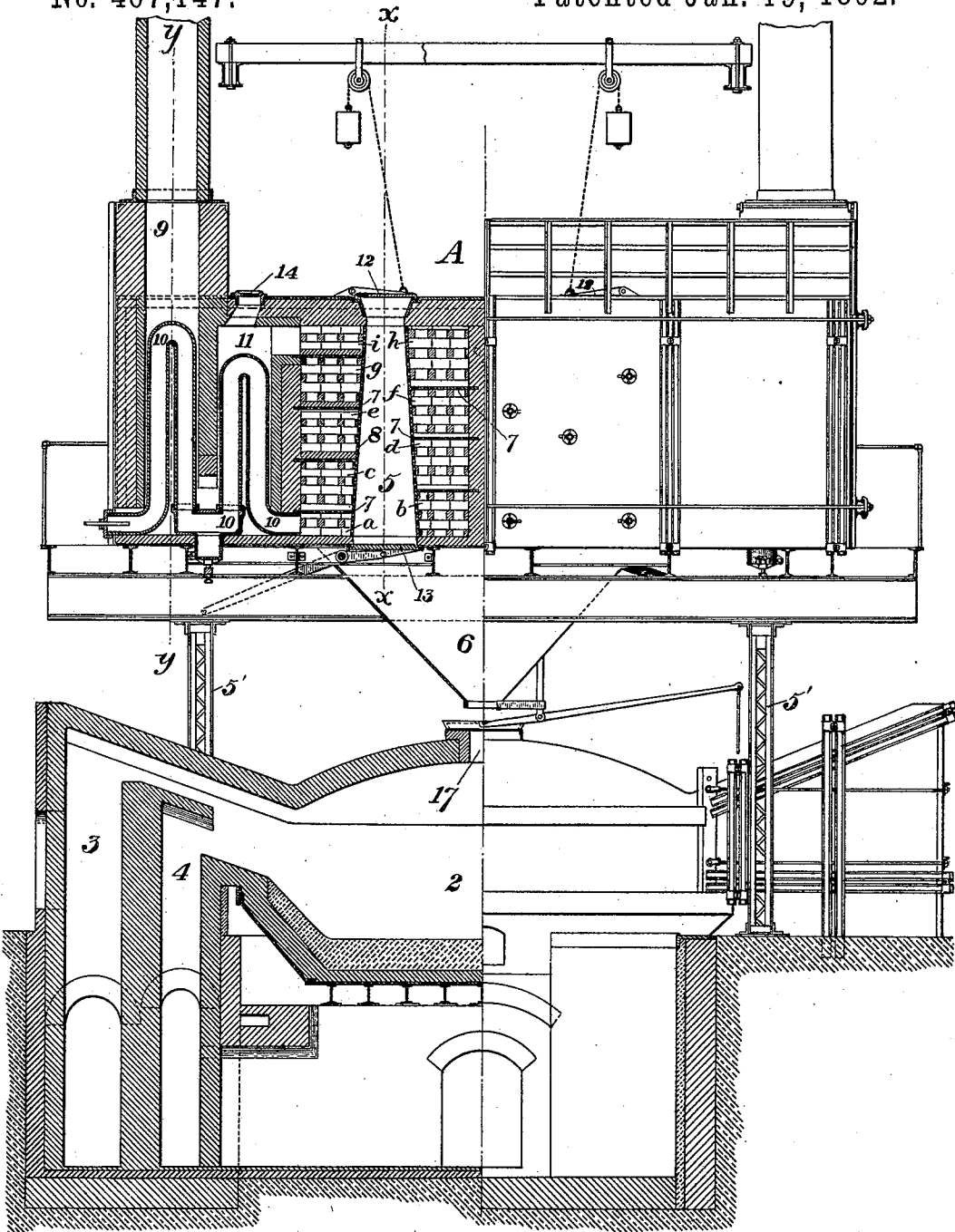
(No Model.)

2.Sheets—Sheet 1.

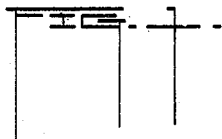
T. S. BLAIR, Jr.
PROCESS OF MANUFACTURING STEEL.

No. 467,147.

Patented Jan. 19, 1892.



Witnesses
S. M. Corum
A. L. Gill



Inventor
Thomas S. Blair Jr.
by *W. Ransdell & Son*
Attorneys

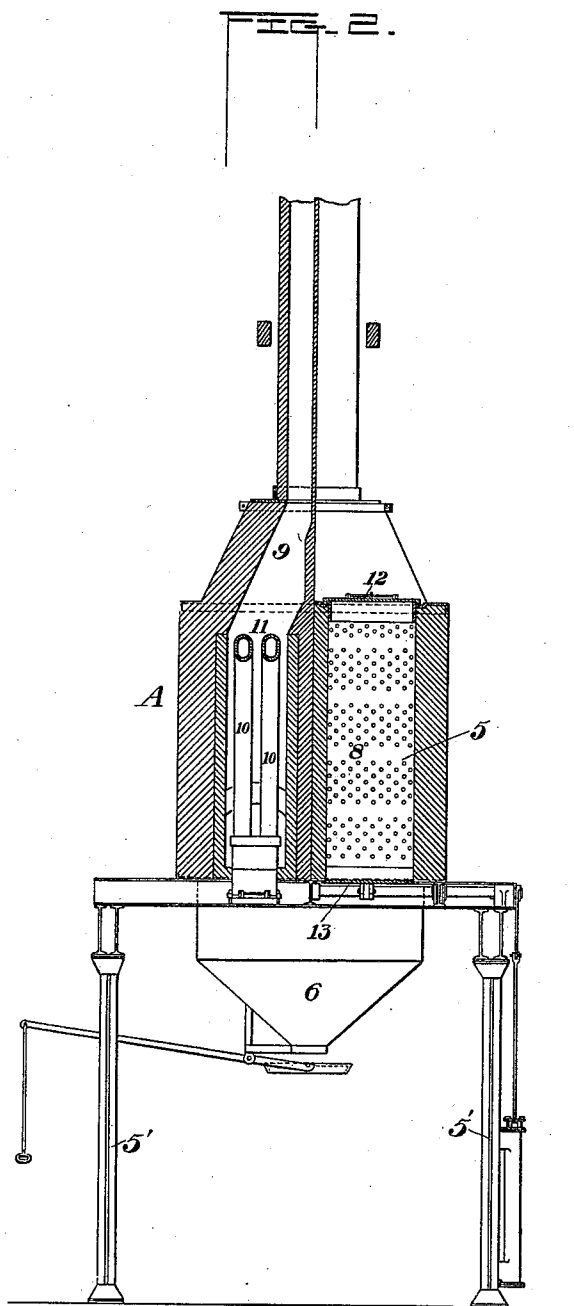
(No Model.)

2 Sheets—Sheet 2.

T. S. BLAIR, Jr.
PROCESS OF MANUFACTURING STEEL.

No. 467,147.

Patented Jan. 19, 1892.



Witnesses
S. M. Corum
H. L. Gill

Inventor
Thomas S. Blair Jr.
by *W. B. Russell & Sons*
Attorneys

UNITED STATES PATENT OFFICE.

THOMAS S. BLAIR, JR., OF ALLEGHENY, PENNSYLVANIA.

PROCESS OF MANUFACTURING STEEL.

SPECIFICATION forming part of Letters Patent No. 467,147, dated January 19, 1892.

Application filed March 2, 1891. Serial No. 383,484. (No model.)

To all whom it may concern:

Be it known that I, THOMAS S. BLAIR, JR., of Allegheny, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in the Manufacture of Steel, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, in which—

Figure 1 is a view showing an open-hearth steel-melting furnace in connection with a reducing-furnace situate above the same and adapted to deliver its reduced charge thereto. One-half of the apparatus is shown in vertical longitudinal section and the remainder in side elevation; but the internal construction of the parts shown in section is the same as that of the corresponding parts shown in vertical section. Fig. 2 is a vertical section of the reducing apparatus, partly on the line x and partly on the line $y y$ of Fig. 1.

This invention relates to the manufacture of steel in the open-hearth furnace, according to the method known as the "Martin" process, which, as usually conducted, consists in melting wrought-iron in a bath of molten cast-iron; and my invention consists in substituting free carbon for the carbon of the cast-iron in its function of lowering the fusion-point of the wrought-iron. Wrought-iron without carbon is exceedingly difficult of fusion, yielding only under a temperature very destructive to the furnace and calling for a lavish consumption of fuel; but at a temperature much below its fusing-point it absorbs carbon rapidly, if the latter be placed in actual contact with it, and becomes fusible at a lower and lower temperature with each new increment of carbon absorbed. I have discovered that if wrought-iron be charged upon the hearth of an ordinary open-hearth furnace working at the ordinary temperature of such furnaces, and small anthracite coal, coke, charcoal, graphite, or other suitable carbonaceous material be thrown over it, the iron surfaces in immediate contact with the carbon rapidly absorb it to an extent that renders the metal thus carburized fusible at that temperature, whereupon that portion of the metal melts and drips down through the underlying body, finally reaching the furnace-hearth, where it becomes the first beginning of a bath. The bituminous coals and other

forms of carbonaceous matter which contain considerable quantities of substances volatilizable at high temperatures are less suitable than those forms which heat up without any notable development of vapor, an operation which tends to bring down the temperature of the furnace. This coating of carbon should not be applied at any one time in quantity sufficient to interfere materially with the communication of the heat of the furnace to the body of yet unmelted iron. By renewing the top-dressing of carbon from time to time as it is taken up and carried away in the molten metal the carburizing and melting operations are kept in action until the whole charge has become liquefied, and it is thenceforth manipulated according to the well-known methods of ordinary open-hearth practice, with the exception of a certain special treatment of the slag, to which further reference will be made in another part of this specification. When the wrought-iron is in the form of scrap or otherwise in such shape as to lie in a loose heap on the furnace-hearth, it will of course facilitate the work if some of the carbon be mingled intimately all through the mass, so that in whatever parts thereof the temperature reaches the carburizing-point work will immediately begin. Again, whatever may be the form of the charge of wrought-iron it will be well that it should rest upon a layer of carbon previously spread over the surface of the hearth, so that an additional source of carbon impregnation should thus be supplied to the bath, rendering the latter a more active solvent of the yet solid portion of the charge. Finally, the fusion may be accelerated as to time or simplified as regards the temperature required, or both, by introducing as an adjunct to the carbonaceous matter any of the substances ordinarily employed in case-hardening, such as sal-ammoniac or equivalent chemical agents. I have further discovered that, even aside from its superior cheapness and excellence, the spongy iron produced by the deoxidation of rich iron ores is by far the most suitable form in which to have the wrought-iron employed in this process. Its cellular structure aids greatly both in the carburization and the fusion. In applying my invention to practice, therefore, I prefer to use a reducing apparatus set over an open-

hearth furnace in a way to permit the reduced ore to drop directly out of the reducing-chamber upon the hearth of the melting-furnace, upon which carbon has previously
 5 been spread, carbon having likewise been mingled with the ore before charging into the reducing-chamber, and, finally, carbon is spread over the surface of the heap of iron
 10 sponge in the melting-furnace, as already described above. The especial advantage which I obtain from this delivering of the hot sponge directly from the reducing-chamber upon the
 15 hearth of the melting-furnace is this: that the heat of the furnace is so slightly checked by the entrance of the red-hot mass that it almost instantly recovers its normal high temperature and in a few minutes raises all the more exposed
 20 surfaces of the sponge to a heat at which carbon absorption goes on rapidly and the inception of fusion speedily follows, whereas if the sponge were delivered into the furnace cold, the chilling of the furnace would be so great and the difficulty of imparting
 25 the heat to a body whose interior would long draw away the heat from the surface so serious that the output of the furnace would be greatly diminished and the process deprived of much of its advantage in cost.

The process which I have described above
 30 is efficient in melting wrought-iron or iron sponge in an open-hearth furnace without the aid of a bath of pig-iron; but I do not wish to exclude from the scope of my claims said process when pig-iron is employed for the
 35 purpose of supplementing the action of the carbon or for affecting the quality of the resultant steel. The slag formed during this process of melting wrought-iron without cast-iron is at first very rich in protoxide of iron,
 40 and if tapped off as soon as formed it would carry away much iron with it. I have discovered a remedy for this consisting in the application to the slag of carbonaceous matter thrown over the surface of the seething
 45 mass with or without the limestone now used as a flux for thinning the slag. The introduction of the carbon serves to intensify the well-known reactions, which cause the slag ordinarily to "clear" by precipitation of its excess
 50 of iron into the metallic bath beneath it.

I do not claim the above-described process of clearing the slag by the addition of carbonaceous matter, since I have made it the subject of a special application, Serial No. 394,043,
 55 filed May 25, 1891.

The following is a brief statement of the preferable manner in which my invention as above described is applied to practical use:
 60 Over the top of an open-hearth steel furnace of ordinary construction I place a reducing apparatus in such a position that the contents of any one or more of its chambers can at will be discharged by a chute through an aperture in the roof upon the furnace-hearth
 65 and of such proportions that it is capable of preparing and continually holding in reserve for use whenever the melting-furnace may be

ready to receive it a charge of iron sponge. At the first beginning of operations I charge the cold crude ore mixed with about five per cent.
 70 of its own weight of carbon into the reducing-chambers (already heated in advance to a red heat) and then turn on the stream of reducing-gas. Meantime the open-hearth or melting furnace has been lighted up at such
 75 time as experience has shown to be requisite in order to have the furnace heated to its normal temperature by the time the first charge of sponge is ready for use. When this time arrives, I throw upon the bare hearth of the
 80 furnace a light coating of carbon, then discharge upon it the contents of one of the reducing-chambers, and then close the furnace for a few moments until it has recovered its heat. I then throw in upon the heap of
 85 sponge lying upon the hearth in a mass small charcoal, coke, anthracite coal, graphite, or other dry carbonaceous material, preferably neither absolutely pulverulent nor coarser than will pass through a sieve of one-inch
 90 mesh, distributing it as evenly over the whole as can conveniently be done and avoiding getting anywhere a greater thickness than will allow the hot mass beneath to show through partially. The doors are now closed
 95 and the maximum heat turned on, observations being taken at intervals to keep trace of the melting process, which is plainly visible from the spy-holes in the doors. When the flowing away of the fused metal has evidently
 100 left exposed other surfaces not sufficiently supplied with carbon, a new top-dressing is given, as in the first instance, and then once more the furnace is left to do its work, and so on until the entire charge of sponge has been
 105 converted into a liquid mass, constituting "the bath" of the ordinary Martin open-hearth process, except that the carburet in this case has been produced on the spot from wrought-iron, instead of, as in ordinary practice, from the simple fusion of cast-iron. The
 110 rest of the heat is made, as in ordinary practice, by melting the solid metal in the fused metal, except that carbon is thrown over the exposed part of the sponge so long as any
 115 remains projecting above the bath. When the entire charge has been brought to a liquid state, the next step is to test the carbon content, and if too high to run it down to the desired point in the usual way with iron oxide.
 120 At this stage of operations, if not before, should a test sample of the slag show an excess of iron present, and the thinning down of the slag with limestone prove insufficient to cause it to clear satisfactorily, I scatter
 125 in over the surface of the agitated mass small lumps of heavy carbon—such as anthracite coal—which shall float partly submerged in the slag because of their weight, but, because of their small size, not reach down through it
 130 and overcarburize the metal. The size I regulate according to circumstances. For example, with heavy anthracite they should be smaller than with coke and both adapted to

the thickness of the slag that may be expected at the time the carbon treatment of the slag is likely to be called for. I usually prefer to tap off the slag, at least in part, before the tapping off of the metal, and in view of this the acceleration of the clearing of the slag, as described, is of much value, more particularly when there is much phosphorus to be got rid of. The rest of the operation of the open-hearth furnace is conducted as usual. The carbon-point adjusted and the slag satisfactory, all that remains is to apply the Mushet manganese alloy and to cast the steel into molds. The furnace-lining is then put in order and a new heat started, going through the same routine as before. The reducing-chambers being always recharged immediately after discharging, the materials for making a heat are always ready before the melting-furnace is ready for them.

By the above-described combination of the deoxidizing, carburizing, and fusing operations I am able, by one continuous process and without necessarily introducing any ferrous material other than the crude ore and the Mushet alloy, to produce ingots of steel possessing all the superiority attending the direct method of manufacture and without any of the expenditure requisite for the construction, equipment, and operation of the blast-furnace.

Where my invention is applied to the manufacture of steel from wrought-iron in form other than sponge, blooms, bars, or scraps of wrought-iron are charged into the furnace instead of the sponge or in supplement thereto. Otherwise the operations are practiced as above described.

Apparatus suitable to be used in the practice of my invention is illustrated in the accompanying drawings, in which 2 represents the hearth of a regenerative open-hearth steel-furnace of ordinary construction, having flues 3 4 at the ends for the admission of gas and air and the exit of the products of combustion. The reducing apparatus A is supported above the furnace on posts 5' and has upright reducing-chambers 5, opening at the lower ends into a hopper 6, which leads to an opening 17 in the roof of the open-hearth furnace. The apparatus shown in the drawings has four of such chambers arranged in two pairs. Each chamber has opposite lateral checker-work divided by horizontal partitions 7, arranged at alternately higher levels, so as to form opposite chambers or passages *a b c d e f g h i*, the checker-work being faced with perforated wall-plates 8. The last of these chambers *i* opens into a discharge-flue 11, which leads in a tortuous course to the stack 9. Gas-supply pipes 10 extend through the discharge-flue and open into the first chamber *a*. Before beginning the reduction of the ore the reducing-chamber and the flue are heated by combustion in the reducing-chamber of gas or coke. The reducing-chamber is then charged with ore introduced through a

charging-door 12, and a reducing gas—*e. g.*, natural gas—is caused to enter the chamber *a* from the pipe 10. This gas, which has been heated in passing through the pipe 10, travels through the ore in the reducing-chamber in a back and forth progressive course, passing in succession to and from the chambers *a b c d e f g h i* in the order named, and finally escapes from the chamber *i* into the flue 10, where it unites with air admitted through a port 12, and, burning, passes to the stack, heating the gas-pipes 10 in its passage and serving to heat or regenerate the gas passing through the said pipes. When the ore has been reduced to a metallic sponge by the action of the reducing-gas, it may be delivered to the hopper by opening the door 13 at the base of the reducing-chamber, and through the hopper it is discharged upon the hearth of the open-hearth furnace. The subsequent treatment of the sponge, by which it is converted into steel, is conducted in the manner described above.

I do not claim herein the apparatus above described, since it is substantially the same as the apparatus for which I have made application for United States Letters Patent, Serial No. 360,183, filed July 28, 1890; nor do I intend to limit my present invention to its use, since for the purposes of this invention the metallic sponge or wrought-iron may be produced in any suitable way.

I am aware that abortive attempts have been made to produce steel in the open-hearth furnace direct from the iron ore by first deoxidizing it on the hearth and then carburizing and melting it there. This method necessarily fails commercially, because of the fatal defect in its theory of employing the costly open-hearth apparatus for the reducing operation, which latter, furthermore, must necessarily be conducted according to the insupportably slow system of deoxidizing by solid instead of gaseous reducing agents.

I am also aware that it has been attempted and with a certain degree of success to manufacture open-hearth steel without a bath of molten pig by charging blooms of wrought-iron upon a bed of open wooden boxes filled with charcoal and raising the temperature of the furnace to so high a pitch that the wrought-iron fuses without carburization, and, trickling down into and through the charcoal, takes up carbon enough therefrom to convert it into steel. This method labors under two disadvantages. In the first place, there is the extra expense of converting the ore into wrought-iron blooms, and, in the second place, the necessity of melting down the wrought-iron without previous carburization, thus calling for a much higher temperature during a much longer time as compared with the temperature and duration of exposure requisite for melting down the carburized iron sponge. The result is the speedy destruction of the melting-furnace.

I am aware, also, that in prior Letters Pat-

ent it has been proposed to manufacture steel by delivering iron sponge from a rotating reducing-muffle through the roof of an open-hearth furnace upon a bed of carbonaceous material previously placed on the hearth, so that as the sponge is melted by the furnace-heat the molten bath may be carburized by the carbonaceous material and may form a carburet bath for the remainder of the sponge, and that as an alternative mode of this process it has been proposed, instead of charging the carbon into the furnace-door, to charge it into the mouth of the rotating muffle before introducing the ore into the furnace. Such process is one in which the wrought-iron is fused merely by action of heat and is carburized when molten, and is therefore essentially different in principle and operation from my invention. I therefore do not claim, broadly, the process of melting down wrought-iron in an open-hearth furnace.

I claim—

1. The process of manufacturing steel, which consists in placing iron on an open hearth and free carbonaceous matter on the surface

of the iron, heating them, thereby causing the surface of the iron to take up carbon, continuing the heating until the carburized portion melts and runs down onto the hearth, and charging another portion of carbon upon the freshly-exposed surface of the iron as the fusion proceeds, substantially as and for the purposes described.

2. The process of manufacturing steel, which consists in placing iron sponge on an open hearth and free carbonaceous matter on the surface of the iron, heating them, thereby causing the surface of the iron sponge to take up carbon, continuing the heating until the carburized portion melts and runs down onto the hearth, and charging another portion of carbon upon the freshly-exposed surface of the iron sponge as the fusion proceeds, substantially as and for the purposes described.

In testimony whereof I have hereunto set my hand this 27th day of February, A. D. 1891.

THOS. S. BLAIR, JR.

Witnesses:

THOMAS W. BAKEWELL,
W. B. CORWIN.