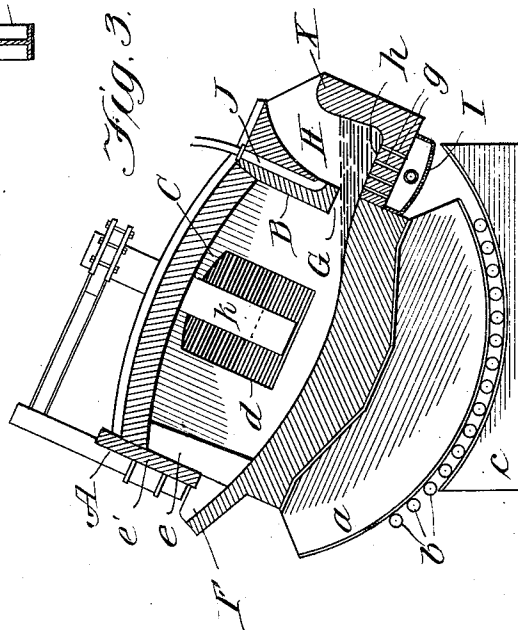
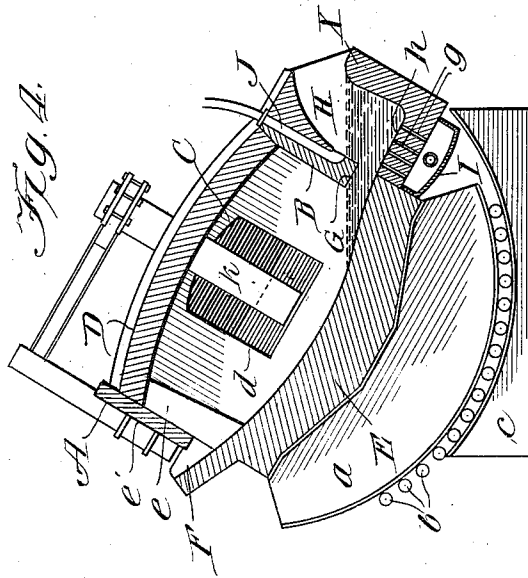
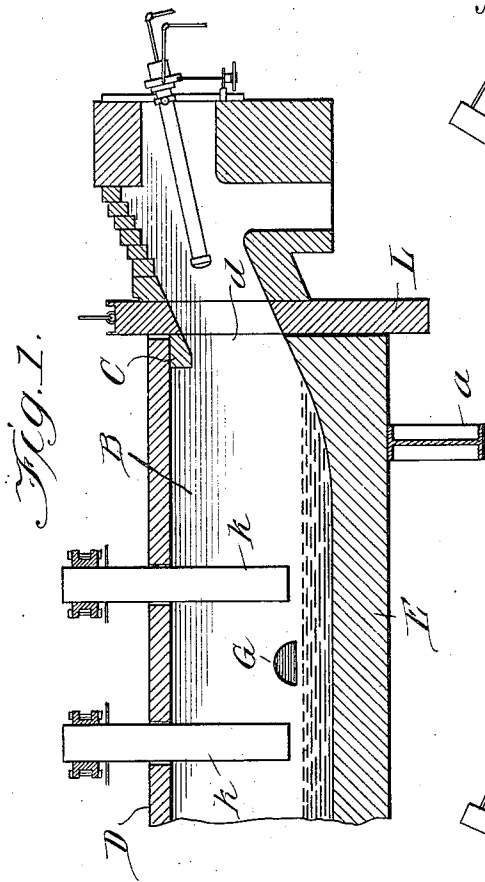


F. B. LAMB.
PROCESS OF MAKING STEEL.
APPLICATION FILED JAN. 3, 1911.

1,036,498.

Patented Aug. 20, 1912.

2 SHEETS—SHEET 1.



Witnesses:
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Fig. 5.

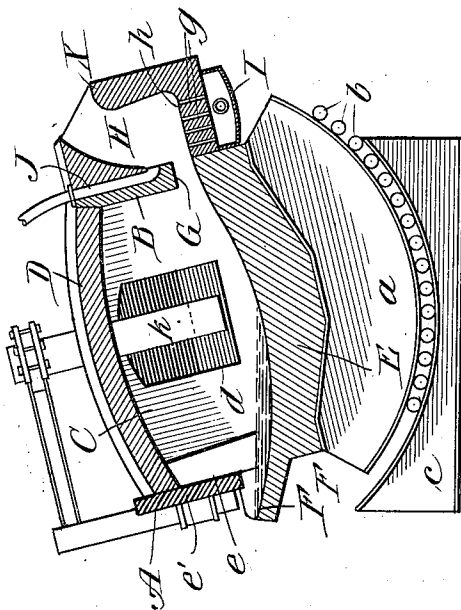
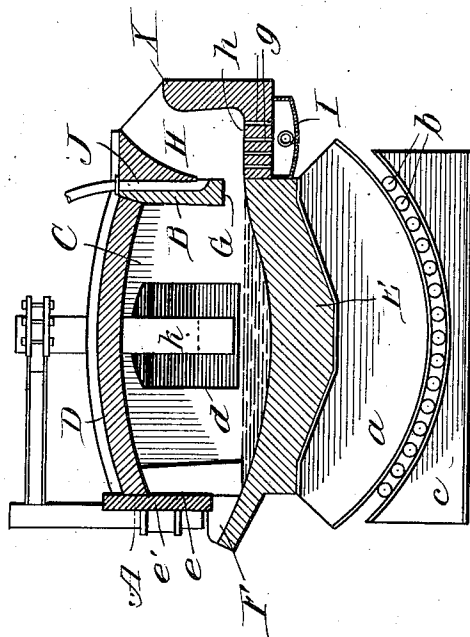


Fig. 6.



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UNITED STATES PATENT OFFICE.

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PROCESS OF MAKING STEEL.

1,036,498.

Specification of Letters Patent.

Patented Aug. 20, 1912.

Application filed January 3, 1911. Serial No. 600,383.

To all whom it may concern:

Be it known that I, FRED B. LAMB, a citizen of the United States, residing at Bettendorf, in the county of Scott and State of Iowa, have invented new and useful Improvements in Processes of Making Steel, of which the following is a full, clear, and exact description.

My invention relates to a steel making process, and particularly to a process involving the best features, only, of a number of well known processes now extensively used.

The principal object of my invention is to produce the highest grade of steel more economically than has ever been heretofore possible.

A further object of my invention is to make possible the use of the very cheapest low grade raw materials without regard to their chemical content and yet bring forth the highest grades of steel.

Yet another object is to so manipulate and interweave several well known processes, in a manner, that the recognized and time-proven superior features only, of each individual process, is to be utilized—using only those features that contribute to the saving of time, and labor and consumption of fuel, eliminating the more expensive and long drawn out stages which cannot be separated from the old processes when used individually.

Still another object is to greatly increase the capacity of a steel furnace and reduce the cost of repairing and maintaining to a point much lower than has heretofore been possible. This I accomplish in the manner hereinafter fully described and as particularly pointed out in the claims.

In the drawings: Figure 1 is a longitudinal section of a portion of a tilting open hearth furnace. Fig. 2 is a transverse central section showing the furnace in the position it will be in during the first step of my improved process. Fig. 3 shows said furnace in the position it will be in during the second step of the process. Fig. 4 shows it in the position it will be in during the third step of the process. Fig. 5 shows the position it will be in during the fifth step of the process.

In the making of steel where hot metal from a mixer or a blast furnace is not available, the open hearth furnace is un-

questionably the fastest and most economical means known for liquefying a cold charge. It is adapted to use the cheapest fuel possible and is, comparatively, most economical in the consumption thereof. When lined basic it has proven the best, cheapest and fastest means for eliminating phosphorus. Its greatest value resides in its ability to bring forth a highly satisfactory grade of steel from raw materials so base and impure that their use in other processes would be commercially impossible.

In the present day practice, the result of the basic open hearth process is the removal or reduction to within safe limits of carbon, silicon, manganese, phosphorus and possibly sulfur. The length of time, amount of labor, fuel and expense required to make the proper reduction, depends largely upon the manner in which the above elements are chemically combined. If the cold charge be high in carbon, liquefaction begins promptly and the entire mass is melted down quickly, but the attending reduction of the carbon to within allowable limits is accomplished only after several hours of painstaking labor and the subjection of the bath to the fierce oxidizing action of the fuel in the presence of iron ore or other oxidizing alloys. If sulfur is also present, further time must be expended, other expensive alloys used and more fuel consumed in what often times proves a futile attempt to reduce it. While it is possible to bring forth a very satisfactory grade of steel from the basic open hearth process, the baser the raw materials the more difficult and more expensive does the operation become and the more damaging to the furnace, necessitating more frequent repairs and greatly increased cost of maintenance. Exposing the bath for several hours to the oxidizing influence of the fuel in reducing the various elements to within their allowable limits sets up another most objectionable condition, viz., occluded gases, resulting in porosity of the finished casting and absence of density in the rolled section.

In my new process I propose to use a tilting basic open hearth furnace principally for melting the cold charge and dephosphorizing, operations in which it excels, leaving to other means, which will hereinafter more fully appear, the completing of the conversion. I thus eliminate the

long, drawn-out, expensive functions, avoiding the evils incident thereto, and confine the use of the open hearth strictly to that which it accomplishes quickest, most thorough and cheapest.

To the extent that the open hearth excels in melting and dephosphorizing, so does the Bessemer converter excel in decarbonizing and desiliconizing. A charge of molten metal subjected to the action of a Bessemer converter will be robbed of its carbon and silicon in a very few minutes with no other fuel than a blast of air. It is in this means that I propose to use in my new process for accomplishing the next phase of the conversion, viz., the reduction to allowable limits of carbon and silicon. This I accomplish in a new and novel manner as will be hereinafter more clearly shown. Again, as will also be shown by intermingling or interweaving the act of Bessemerizing with that of melting and dephosphorizing in a new and novel manner, highly beneficial, and, I believe, entirely new conditions are set up, conditions contributing to the lowering of cost, the increasing of output and the possibility of using raw materials without regard to their chemical content—conditions that cannot be developed in the separate use of the old processes.

The electric furnace, in the making of steel, it is generally conceded, is a disappointment as a melter of a cold charge. Its extravagant consumption of electrical energy (when produced by means other than water power) makes its use commercially impossible. But as a means for reducing sulfur, deoxidizing and driving out occluded gases it is unexcelled. In my new process the electric process will be employed solely as a refining means and as the molten mass as well as its container will be previously brought to a very high temperature and otherwise favorably prepared, the duration of the electrical treatment will be confined to the minimum, in fact shortened to such an extent that its use is not only not commercially prohibitive but will actually contribute to the economic feature of the entire process.

While this application is for a patent for a process and not for a mechanism, the latter forming the subject-matter of a co-pending application (filed by me February 28, 1911, Serial Number 611,409), the process will be the more readily understood by a reference to the apparatus. One of the new and novel features, one that distinguishes it from the entire prior art, resides in accomplishing my entire process in one unit—a single furnace. While it is old in the art, and common practice to convey hot metal long distances from a blast furnace or mixer to a Bessemer converter, and again, long distances from the converter to an elec-

trical furnace, or in other processes to serve an open hearth furnace with hot metal and convey it from there to an electric furnace, or again to serve a Bessemer converter with hot metal and convey it from there to an open hearth furnace, my process is the first to melt, convert and electrically refine in one vessel or furnace, whereby steel of the highest grade can be made from the basest cold materials in a plant where hot metal from the blast furnace is not available, and accomplish this with all the economies afforded by the presence of the blast furnace and cheap electricity.

In view of the foregoing, it will be apparent, in the light of what follows, the most convenient form of furnace for the economical application of my new process is a modified form of the tilting open hearth, basic lined, and provided with an auxiliary "blowing" chamber and also being capable of a quick conversion into a highly efficient electric furnace. In the drawings this furnace is shown to consist of the usual front and rear walls, A and B; end walls C; arched roof D; and concaved basic lined bottom E. The bottom is supported by two or more rockers, *a, a*, that rest upon anti-friction rollers, *b, b*, which latter are seated in concaved tracks, *c, c*, the curvature of which is struck from the center of the gas port, *d*, in the end walls of the furnace. The furnace therefore, tilts on the axis of its gas ports, and the latter can continue to provide the fuel and the furnace continue to operate when in a tilted position, as well as when in its normal upright position, as shown in Fig. 3 of the drawings. In order, however, to practically seal the furnace during the refining process, which will hereinafter be more fully described, I provide these gas-ports with vertically movable gates *L*, that are adapted to be raised and lowered from the outside.

The center of length of the front walls of the furnace is provided with a charging port, *e*, which is normally kept closed by a suitable door, *e'*, and immediately below this door is a discharge spout, *F*, the bottom of which is a continuation of the basic lined bottom inside the walls of the furnace. At a point diametrically opposite the spout, the opposite side wall is provided with a low arched passage, *G*, the floor of which is a lateral continuation of the bottom of the furnace. This passage leads to a Bessemer converter, consisting of a chamber *H*, the exterior walls of which are rectangular and project out from and are suitably supported by the side-wall of the furnace. The bottom, *h*, of said chamber is built so that its upper surface is in the same plane as the floor of the passage *G*, and it is perforated by a series of air-ducts, *g*, that receive air from the air-box, *I*, below. The front

wall of this chamber terminates a suitable distance below the rear wall and the upper edge of said front wall is rounded on the inner side to form a lip, *x*, and the inner surface of the rear wall is curved so as to overhang the chamber when the furnace is tilted toward the converter. The side portion of the wall of the furnace forming the inner wall of the converter is provided with a downwardly extending air-flue, *J*, from the upper end of which a pipe extends leading from a suitable air pressure supply. The lower end of this flue is deflected side-wise into the converter chamber at a point above the arch of passage and below the plane of the upper edge of the outer wall of the converter, when the furnace is in its normal position.

Extending down through the roof or arch of the furnace are two electrodes, *k*, *k*. These electrodes are adjustable vertically, and their lower ends are designed to terminate at the most desirable point to establish the electrical current during the refining operation.

The operation of my improved process is substantially as follows: Presuming the hearth to have a capacity of, say, fifteen tons, after the furnace has been raised to the proper temperature, in the ordinary manner, the lime-stone would be charged first, and then fifteen tons of cheap low grade pig iron, or part pig and part steel scrap or cast scrap or cast borings. As the carbon contents of all pig charge would be very high, oxidation would begin promptly and the entire charge would be melted down in about two hours. When about five tons of molten metal had accumulated in the bath, after the blast had been turned into the converter through the air-ducts in its bottom, the furnace would be tilted into the position shown in Fig. 3 of the drawings, permitting the metal to flow through the passage, *G*, into the converter. In about five or ten minutes this five ton mass of molten metal in the converter would be thoroughly decarburized and desiliconized, and its temperature raised from 1,800 degrees Fahrenheit, which it possessed within the furnace, to about 3,000 degrees. While the metal is being subjected to the action of the air in the converter, considerable highly acid slag is developed. In order to remove this, the furnace is tilted farther in the same direction, as shown in Fig. 4 of the drawings, and until the level of the surface of the metal will reach the lip or upper edge of the outer wall of the converter so as to allow the slag to drain off. This highly acid slag is removed and not permitted to flow back into the bath simply to lessen the difficulty that would follow in keeping the lime slag in the melting hearth in the best possible condition—it

leaves just that much less to contend with. It could be returned to the bath without injury to the furnace lining owing to the charges of basic material (such as lime) which was introduced into the melting hearth initially, sufficient lime having been supplied to satisfy the silica of the slag and thus save the lining. The removal of the slag in this manner may be expedited or materially assisted by directing a blast of air from the mouth of the air-flue, *J*, laterally across the surface of the metal, substantially as shown. The furnace is then tilted back to its normal position, and as the furnace has been made to tilt with the gas ports as an axis, the melting operation in the hearth proper has not been interrupted during the act of "blowing" the five tons of metal in the converter. When, therefore, the furnace is made to resume its normal position, this five tons of metal, at a temperature of 3,000 degrees Fahrenheit, flows back into and mixes with the bath, and materially raises the temperature of the entire bath, and greatly hastens the reduction of the unmelted portion of the charge at a great saving of fuel. After the metal has been in the converter it is thoroughly impregnated with oxidizing gases, due to the action of the air blown through it, and when the furnace is made to resume its normal position, the carbon in the bath will most eagerly combine therewith, acting exactly as iron ore does in ordinary practice. This fact avoids the necessity of using iron ore as an oxidizing agent, and this effects another great saving of labor, time and fuel. While the operation of my improved process has been proceeding in the manner hereinbefore described, dephosphorization, through the action of the lime slag, has gone on uninterruptedly. If a test is now made, and shows too much carbon, another five tons can be "blown" in a few minutes in the converter, as before, each time gaining in the removal of a large portion of highly acidulous slag, and in a greatly increased temperature of the bath. At the end of about two hours' time the entire charge will be melted, decarbonized, desiliconized, dephosphorized and brought to a very high temperature. There remains to be eliminated the most difficult ingredients with which steel making processes have to contend, and that is sulfur and occluded gases. While sulfur can be eliminated, or at least much reduced in the open hearth furnace, this can only be accomplished at the expense of much time, fuel and expensive alloys, and the development of the steel maker's worst foe, viz., occluded gases, caused by the continued exposure of the bath to the oxidizing influences of the fuel, resulting in porous castings and loss of density in rolled sections. The electric process is therefore, now

brought into requisition to desulfurize, de-oxidize and liberate these occluded gases. Therefore, when the bath is properly decarbonized, desiliconized and dephosphorized, the gates L_1 are raised so as to close the gas ports, and practically seal the furnace, and then the electrodes are lowered into position, and the current applied to the bath for about an hour resulting in a bath of the highest grade of steel obtainable ready for pouring. The furnace is then tilted in the direction as shown in Fig. 5 of the drawings, and contents drawn off through the pouring spout into any ladle ready for teeming.

While my process is thus described to consist primarily of melting the cold charge and dephosphorizing in the hearth portion of a basic lined open hearth furnace; then removing a portion or portions of the melted metal to an auxiliary chamber forming a Bessemer converter where it is promptly decarbonized and desiliconized and raised to a high temperature; then the drawing off the highly acid slag from the converter; then returning this metal to the parent metal; then sealing the furnace against the oxidizing influence of the fuel, and then the final refining in the removal of sulfur and occluded gases by the application of the electric current, I do not confine myself to the production of steel from a cold charge. Hot or melted metal from the blast furnace, cupola or mixer can be introduced into the melting chamber just as well as cold raw materials and the most satisfactory and economical results follow from the application of my process. Again, the process may be modified by eliminating the electric treatment as a refining means by confining the raw materials used to such as show a chemical content, the refining of which will come within the refining powers of the ordinary open hearth furnace.

What I claim as new is:

1. The process of making steel consisting of liquefying in an oxidizing atmosphere, blowing or bessemerizing without interrupting liquefaction, and then refining in a non-oxidizing atmosphere, all without removal from the one vessel or furnace.

2. The process of making steel consisting of melting a charge by the use of gas or oil fuel, blowing or bessemerizing without interrupting the melting operation, then refining in a non-oxidizing atmosphere, all without removal from the one vessel or furnace.

3. The process of making steel consisting of melting a charge in an oxidizing atmosphere, blowing or bessemerizing a portion of the melted charge without interrupting the melting operation, then refining in a non-oxidizing atmosphere, all without removal from the one vessel or furnace.

4. The process of making steel consisting of melting a charge in an oxidizing atmosphere, then when a given amount of melted metal has accumulated, removing it from the melting chamber and greatly increasing its initial temperature by subjecting it to an air blast in a converting chamber, without interruption to the melting operation, then restoring the higher heated mass to the melting chamber, then refining the entire mass in a non-oxidizing atmosphere, all without removal from the one vessel or furnace.

5. The process of making steel consisting of melting a charge in an oxidizing atmosphere, and without interrupting the melting operation, removing a portion of the melted mass, greatly increasing its temperature, returning it to the melting chamber to assist and hasten liquefying the unmelted portion of the charge, all without removal from the one vessel or furnace.

6. The process of making steel consisting of melting a charge in an oxidizing atmosphere, separating therefrom and blowing or bessemerizing a portion of the melted charge, removing the resultant slag from the blown mass, restoring the blown mass to the melting chamber, without interrupting the melting operation, and all without removal from the one vessel or furnace.

7. The process of making steel consisting of melting a charge in the oxidizing atmosphere of a melting chamber, separating therefrom and blowing or bessemerizing a portion of the melted charge, removing the resultant slag from the blown mass, returning the blown mass to the melting chamber, without interrupting the melting operation, then refining in a non-oxidizing atmosphere, all without removal from the one vessel or furnace.

8. The process of making steel consisting of subjecting a bath of melted metal to the influence of gas or oil fuel, removing a portion of the bath to an auxiliary blowing or bessemerizing chamber, returning the blown mass to the parent bath, without interrupting the continued action of the fuel on the parent bath, all without removal from the one vessel or furnace.

9. The process of making steel consisting of subjecting a bath of melted metal to the oxidizing influence of gas or oil fuel, blowing or bessemerizing a portion of the bath; removing the resultant slag from the blown mass, returning the blown mass to the parent bath, without interruption of the action of the fuel on the parent bath, then refining the entire mass in a non-oxidizing atmosphere, all without removal from the one vessel or furnace.

10. The process of making steel consisting of liquefying and dephosphorizing in an oxidizing atmosphere, decarburizing and desiliconizing in a blowing chamber, with-

out interrupting liquefaction and dephosphorization, desulfurizing and deoxidizing in the absence of oxidizing influences, all without removal from the one vessel or furnace.

11. The process of making steel consisting of melting a charge and removing phosphorus by the use of gas or oil fuel in the presence of lime slag, removing a portion of the charge as soon as melted to an auxiliary blowing or bessemerizing chamber, eliminating carbon and silicon therefrom, drawing off the resultant slag from the decarburized and desiliconized mass, returning the blown metal to the parent mass, all without interrupting the melting and dephosphorizing operations and all without removal from the one vessel or furnace.

12. The process of making steel consisting of melting the charge and dephosphorizing same by the use of gas or oil fuel in the presence of lime slag in the melting chamber of a basic lined open hearth furnace; removing a portion of the melted metal to an auxiliary chamber where it is decarburized and desiliconized by blowing or bessemerizing; drawing off the resultant slag from the blown mass, and returning the decarburized and desiliconized metal to the parent mass, all without interrupting the melting and dephosphorizing operation, and then sealing the furnace against the oxidizing influence of the gas or oil fuel, desulfurizing, deoxidizing and eliminating occluded gases in this non-oxidizing atmosphere by the use of an

electric current, all without removal from the one vessel or furnace.

13. The process of making steel consisting of liquefying by oxygenous heat, blowing or bessemerizing a portion of the liquefied mass, without interrupting continued liquefaction; returning the blown mass to the parent mass without interrupting liquefaction, all without removal from the one vessel or furnace.

14. The process of making steel consisting of liquefying in an oxygenous heat, and refining partly in a communicating chamber and partly in a non-oxygenous heat, all without removal from the one vessel or furnace.

15. The process of making steel consisting of refining metal partly in the oxygenous heat of a hearth, partly in a communicating chamber and partly in a non-oxygenous heat without removal from the one vessel or furnace.

16. The process of making steel consisting of liquefying and partially refining in an oxygen heat, partially refining in a communicating chamber and final refining in a non-oxygenous heat, without removal from the one vessel.

In witness whereof I have hereunto set my hand this 29th day of December 1910.

FRED B. LAMB.

Witnesses:

A. B. FRENIER,

HENRY BELLINGHAUSEN.