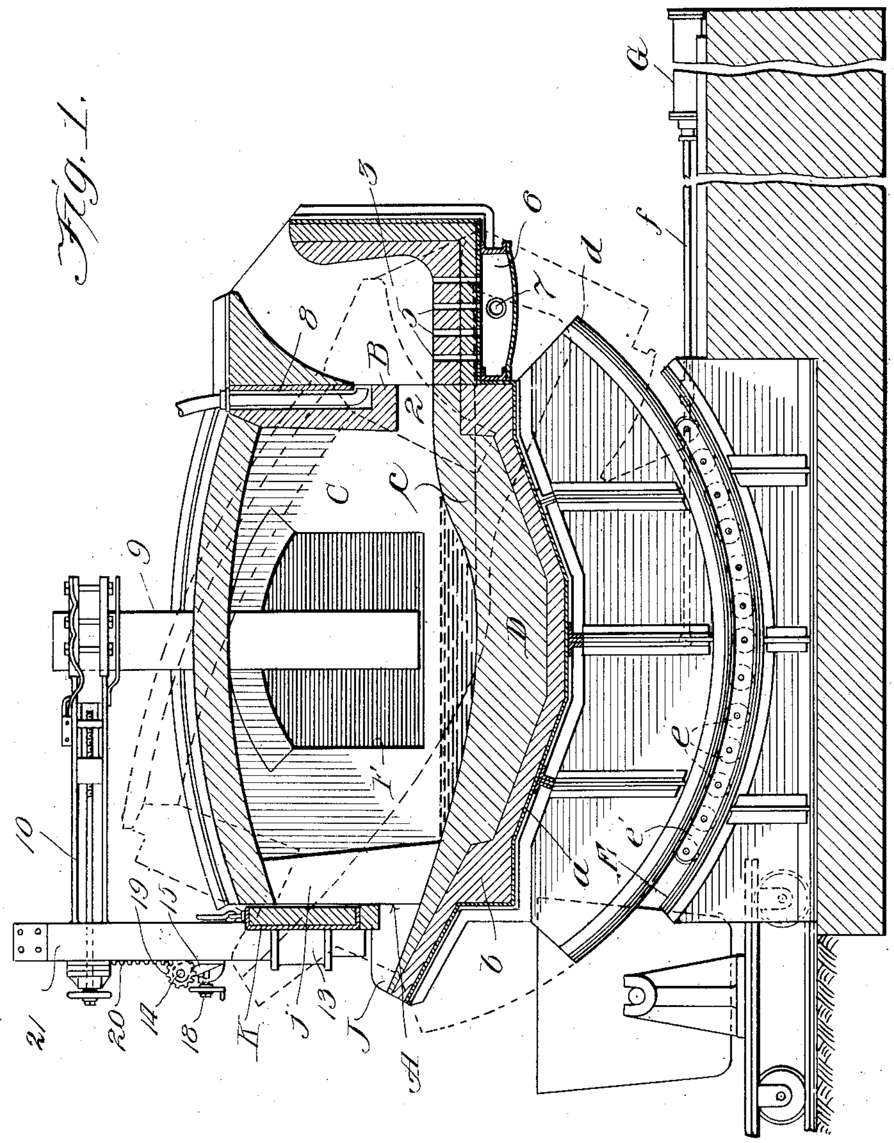
F. B. LAMB.

METALLURGICAL FURNACE.

APPLICATION FILED FEB. 28, 1911.

1,036,499. Patented Aug. 20, 1912.

4 SHEETS—SHEET 1.



Witnesses:

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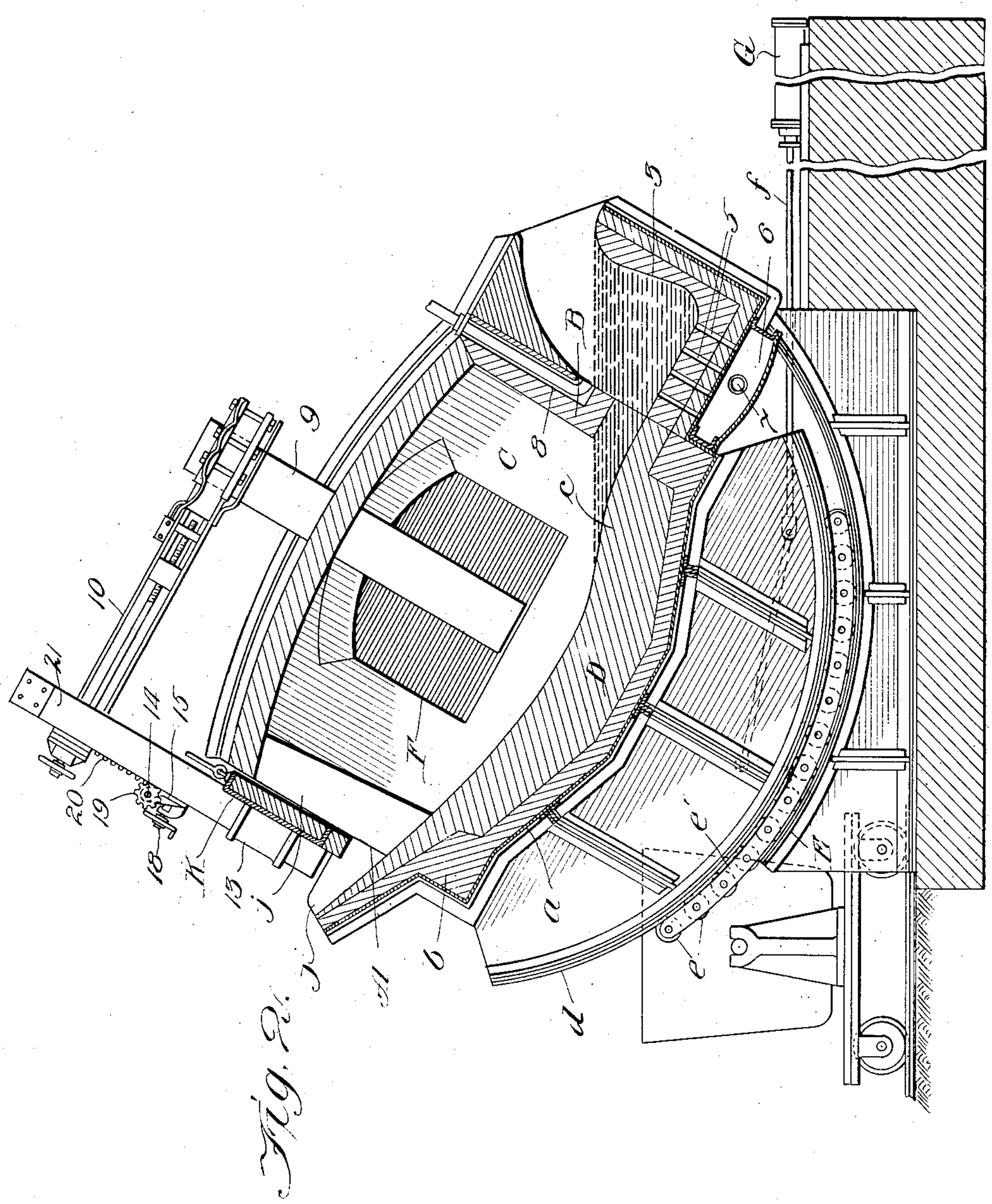

Fig. 2.

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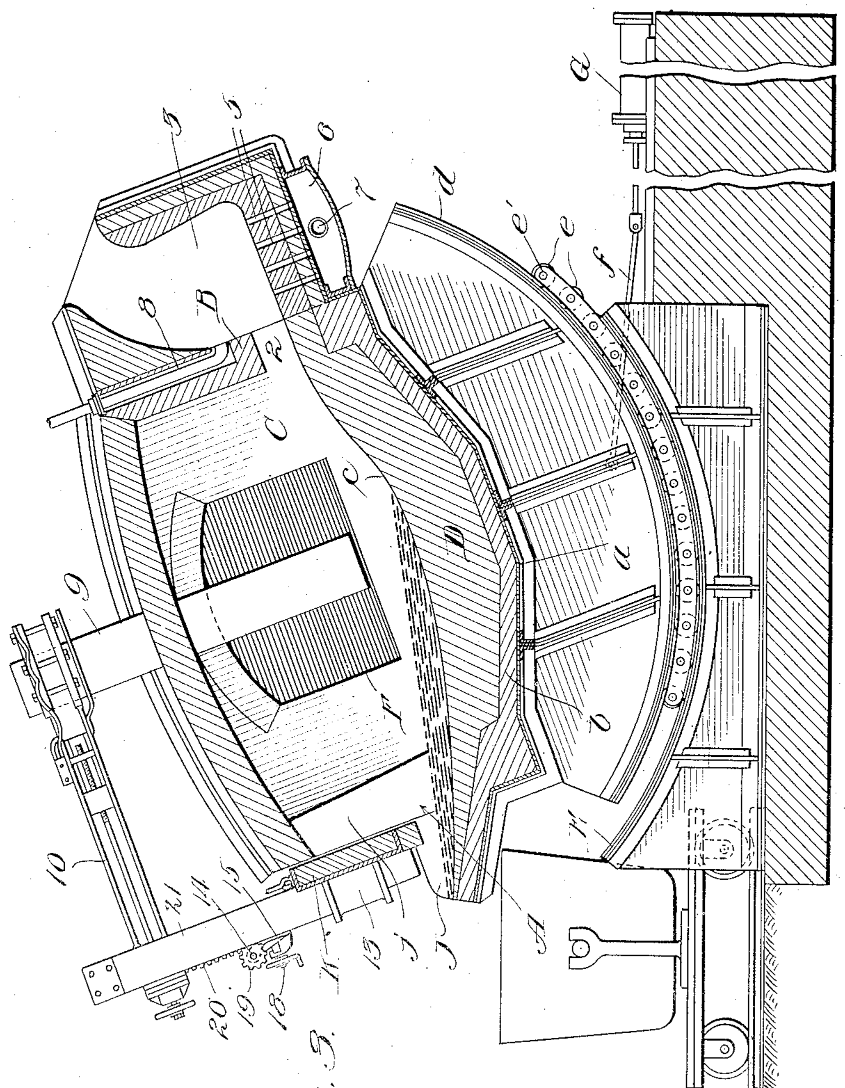

Fig. 3.

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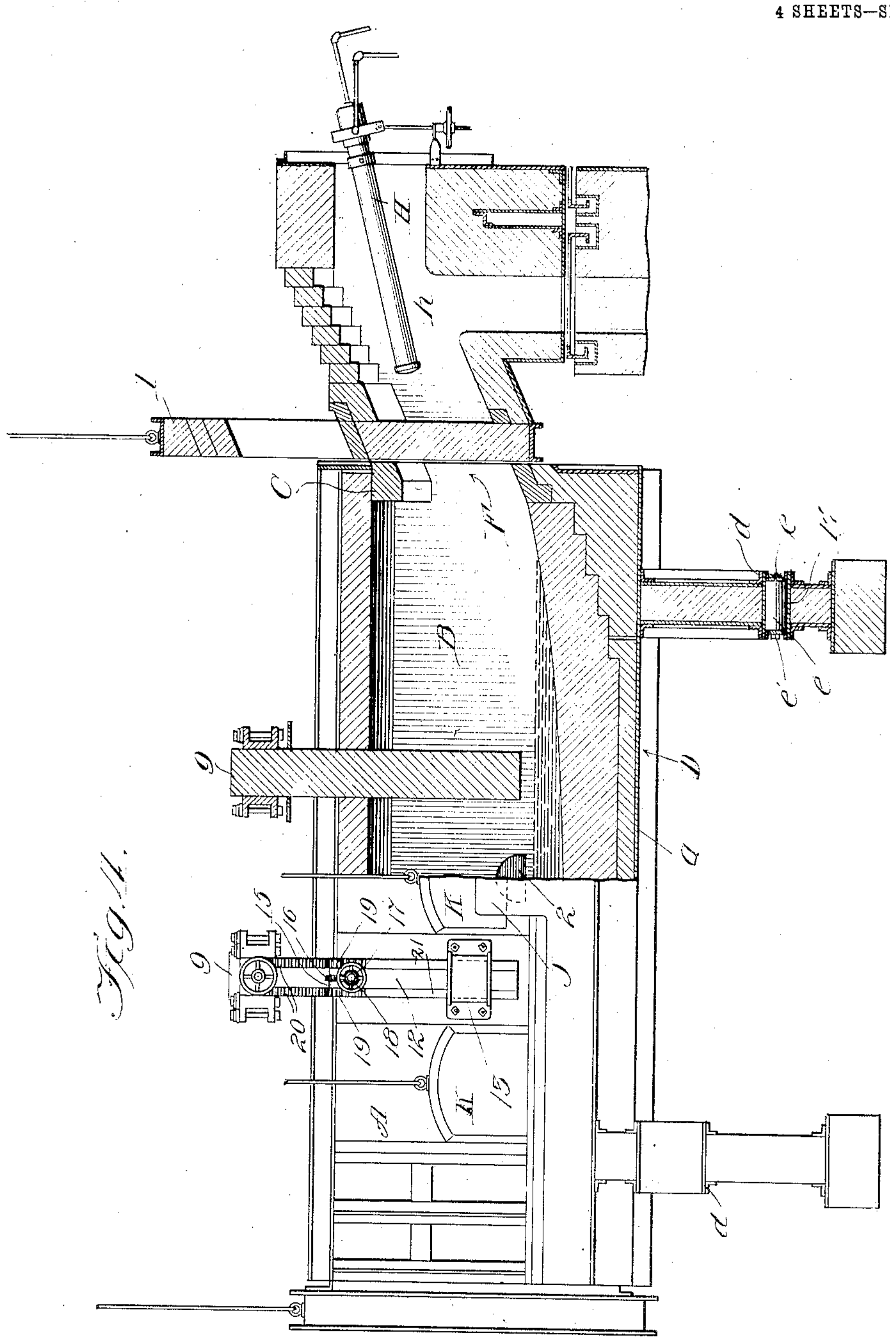

WITNESSES

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UNITED STATES PATENT OFFICE.

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METALLURGICAL FURNACE.

1,036,499. Specification of Letters Patent. **Patented Aug. 20, 1912.**

Application filed February 28, 1911. Serial No. 611,409.

To all whom it may concern:

Be it known that I, FRED B. LAMB, a citizen of the United States, residing at Bettendorf, county of Scott, and State of Iowa, have invented certain new and useful Improvements in Metallurgical Furnaces, of which the following is a specification.

My invention relates to metallurgical furnaces, substantially in accordance with the requirements of a new process of making steel, as set forth in an application for Letters Patent of the United States filed by me January 3d, 1911, Serial No. 600383.

The invention embodies a modified form of the class of furnaces generally known as the tilting open hearth furnace of the regenerative type, provided with a "blowing" or converting chamber and capable of a quick conversion into an electric furnace.

The principal object of my invention is to produce a furnace, which, when used for making steel, permits of the use of the lowest grades of raw materials and yet bring forth the highest grade of steel with a degree of economy heretofore impossible.

Another object of my invention is to greatly reduce the cost of maintenance and largely increase the output.

Still another object of my invention is to make possible the use of electrical energy as a refining element without increasing the cost of the finished product beyond that resulting from other methods.

These and other objects I accomplish by the improvements hereinafter fully described and as particularly pointed out in the claims.

In the drawings: Figure 1 is a transverse section of a tilting furnace embodying my improvements. Fig. 2 is a similar view showing the furnace tilted toward the converter. Fig. 3 is a similar view showing the furnace tilted in the opposite direction for "pouring". Fig. 4 is a view showing one-half of the furnace in longitudinal central section and the other half in side elevation.

The electric furnace, the latest contribution to the art of steel making, has proven 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 prohibitive. But as a means for refining by reducing sulfur and deoxidizing, it is unexcelled and has proven its worth even at a slight increase in cost of finished product.

In the present day practice it is customary to charge the electric furnace (a specially constructed unit) with hot metal which had been previously prepared by having been acted upon by an open hearth furnace or converter. Where metal from a blast furnace is available, it is generally conveyed to a mixer and from there conveyed often times long distances to a converter, where it is "blown" for carbon and silicon and again ladled and conveyed long distances to the electric furnace for refining and finishing. It is also the practice to convey hot metal to an open hearth furnace for the elimination of phosphorus and then conveyed to the electric furnace for finishing. Again the basic open hearth has been charged with cold metal, where it is melted and phosphorus, carbon and silicon reduced to allowable limits, and then conveyed to an electric furnace for refining. In all these methods, separate mixer, separate open hearth furnaces, separate converters and separate electric furnaces are employed, resulting in the excessive loss of initial heat of the metal due to the frequent ladling and conveying long distances and pouring from one vessel to another. Much of the time, fuel and expense incident to such procedure is expended in restoring this lost heat of the metal and its various retainers—an expense seriously effecting the final cost of the finished product.

The open hearth furnace is unquestionably the fastest and most economical means known for liquefying a cold charge and when lined basic it is unexcelled for the elimination of phosphorus. The converter, either of the "bottom", "side" or "surface" blow type excels in the elimination of carbon and silicon. I have therefore designed a furnace in which will be found confined in a single unit the tilting open hearth—the converter and the electric, so arranged and coöperating in such a manner that recognized and time-proven superior features only, of each individual furnace, is to be utilized—using only those features that contribute to the saving of time, labor and fuel, eliminating the more expensive and long drawn out operations which cannot be separated from these devices when used individually. This kind of a furnace comprises a substantially rectangular body having a front wall A, a rear wall B, end walls C, a bottom D and a roof. The bottom or floor consists of a supporting metal retaining sheet *a*, which, between its parallel upwardly flanged side edges is concaved or dished and provided with the ordinary silica brick lining *b*, which, in turn is covered with the material *c* for either an acid or basic lined bottom.

The shell *a* is reinforced both longitudinally and transversely, and near its ends it is provided with corresponding rockers, *d*. The curved treads of these rockers rest and travel upon a series of segmentally arranged anti-friction rollers, *e*, that are journaled at equal distances apart in parallel segmental frames *e'*, and these rollers rest and travel upon concaved tracks E built upon a suitable foundation. The end walls C of the furnace are provided with the usual gas or fuel ports F, through which the gas from the burner H and heat from the regenerative chambers (not shown) through the flues *h* are blown into the furnace.

A vertical movable gate I is interposed between the end wall of the furnace and the mouth of the intake flue *h* which has an opening of such shape and dimension in its upper portion that when it is in its lowered position the communication between the intake flue and the fuel-ports is unobstructed. The lower portion of this gate, however, is imperforate, and when the gate is raised sufficiently it closes the fuel-ports and seals the furnace. The curved treads of the rockers *d*, and the concaved tracks E are struck from an axis intersecting the center of the fuel-ports, so that, no matter in what tilted position the furnace may be, the heat products will continue to blow into the furnace. The furnace may be tilted or rolled through the medium of a hydraulic cylinder G having a ram or piston *f* which connects with the center of length of one of the rockers, at a point above its tread.

The front wall A of the furnace is provided with the usual charging doors. The lower portion, of the central charging door opening is formed by the bottom of the furnace being extended out under this doorway forming the bottom of a pouring spout J, the side edges of which are raised sufficiently to confine the metal when pouring. This charging doorway is opened and closed by a vertically movable gate K, which is operated through the medium of a chain or cable by suitable mechanism (not shown). Opposite the charging door-way, the rear wall of the furnace is provided with a comparatively small opening 2, which communicates with a blowing chamber or converter 3 at a point next the bottom thereof, which latter and the floor of said opening are a continuation of the bottom of the furnace. This "blowing chamber" or converter 3 is built out from and removably attached to the rear wall of the furnace. Its outer shell may be of rectangular shape and is made of sheet metal. It is lined by a course of brick and by an inner lining of the composition usually employed for lining converters. The inner contour of the inner lining is of flask shape with the mouth or opening drawn to one side as shown. This converter is retained in place against the rear wall of the furnace by any suitable means, such as lugs and key-wedges (not shown). Its outer wall terminates below the plane of the inner wall, and is constructed so that slag from the metal therein can be drawn or blown off, as will hereinafter more fully appear. The upper part of the inner wall is built out so as to overhang, forming a partial roof of the converter. At the bottom the inner wall is provided with an opening, which is made to register with opening 2 in the rear furnace wall when converter is clamped thereto. The bottom of the converter is provided with a series of openings or twyers 5, communicating with an air-chest or box 6, that is supplied with air under pressure from an air intake 7. A vertical passage 8 is provided in the rear wall of furnace immediately above and separate from opening 2. Its lower end is projected outward and discharges into the converter through opening provided. If desired a suitable air blast pipe may extend down through this passage, through which a suitable blast of air may be blown, or the passage may be suitably prepared for doing this. While a "bottom blow" converter is thus shown and described, it is evident that a "side blow" or a "surface blow" type of converter could be used.

At suitable points two or more large corresponding electrodes 9, 9, extend down through suitable openings in the roof of the furnace. The upper ends of these electrodes are suitably secured in the overhanging rear ends of horizontal arms 10, 10, the forward ends of which are rigidly fastened in the upper ends of vertically disposed uprights 12. I do not wish to be confined to the construction of the means shown for supporting these electrodes, but whatever means are employed, I prefer them to be such that the electrodes can be adjusted. As shown in the drawings, these uprights 12 extend down between two vertical side members, 21, the lower ends of these side members are suitably secured to U-shaped frames 13, bolted to the front wall of the furnace. The upper end of these side members are united by a suitable cap, and below this cap the upright 12 is sandwiched between the side members.

At a suitable point uprights 12 have a

transverse shaft 14 journaled in bearings 15, secured thereto, which is revolved through miter gears 16, 17 or worm gearing (not shown), by a shaft 18 extending at right angles thereto and journaled in a frame permanently attached to said arm. Shaft 18 has a suitable wheel mounted on its front end with which to revolve it, and when this is done, and shaft 14 turned, gears 19 on the ends thereof engage racks 20 on the front edges of the parallel side members, raise or lower said arms and the electrodes carried in the overhanging ends thereof.

While I have thus described a specific means of applying electricity to the melted metal that can be adjusted or withdrawn from the bath, it is obvious other means could be adapted without departing from the spirit of my invention which resides broadly in the use of means which may be properly adjusted while in use and while other agencies are performing their particular function in the reduction of the metal.

The furnace as above described is adapted particularly to the making of the highest grade of steel from raw materials so base and impure that their use in any other furnace known to the art would be commercially prohibitive.

While the open hearth furnace, of the present day practice, when lined basic, removes or reduces to within allowable limits, carbon, silicon, manganese, phosphorus and possibly sulfur, the length of time, and amount of labor, fuel and expense required to make the proper reduction, depends altogether 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 the 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. If sulfur is also present further time must be expended and more fuel consumed in what oft times proves a futile attempt to remove it. While it is possible to bring forth a very satisfactory grade of steel from the basic open hearth furnace, the baser the raw materials, the more difficult and more expensive does the operation become and the more damaging to the furnace, due to the long exposure to the fierce action of the fuel, necessitating more frequent and expensive repairs and greatly increased cost of maintenance.

Confining its use to that which it accomplishes quickest and best, namely, melting and dephosphorizing, leaving the reduction of carbon, silicon and sulfur to other means, the first step toward lowering cost of production is achieved. While the electric furnace has proven itself capable of producing steel from a cold charge of cheap low grade base raw materials, the extravagant consumption of electrical energy is such as to render its use commercially prohibitive, but if its use be confined to desulfurizing and deoxidizing after the bath has been brought to a most favorable condition by other means, its use actually becomes a matter of economy and the second step toward lowering cost of production is taken. As the open hearth excels in melting and dephosphorizing and the electric furnace in desulfurizing and deoxidizing, so does the converter excel in removing carbon and silicon. My improved furnace combines these three well known agencies and their individually superior functions are so manipulated that the highest grade of steel is brought forth from materials and at a cost heretofore impossible.

The operation of my improved furnace is substantially as follows: After the hearth or melting chamber, which is lined basic, has been raised to the proper temperature, lime stone is charged to form a slag, then 15 ton (presuming the furnace to be of 15 ton capacity) of cheap low grade pig iron, or part pig and part steel scrap, or all cast scrap or cast borings. As the carbon content of an all pig charge or of a cast scrap charge would be very high, liquefaction will begin promptly and the entire charge will be melted down in about two hours. While a regular open hearth furnace would melt this high carbon charge just as quickly, the attending reduction of this carbon and silicon to within allowable limits can only be accomplished at the expense of much labor and hours of time. It is this feature of steel making by the open hearth that creates expense and contributes to the high cost of the finished product. If metal of lower carbon be charged into an open hearth furnace, such as a half pig and half steel charge, it will naturally take less time and expense to reduce the carbon to within allowable limits, but this gain will be offset by the increased time taken to melt, so that what is saved in one direction is lost in another. In order to keep carbon and sulfur low as possible, half select pig and half select steel scrap are usually used in open hearth practice. This is high priced material. A low grade cheap pig iron could be used at a great saving, if its first cost were not offset by the excessive expense incurred in reducing carbon and other injurious elements.

In my improved furnace the open hearth department will not be called upon to perform this expensive part of the process, but confined solely to melting and dephosphorizing, for, as soon as about 5 tons of melted metal has accumulated in the bath, the blast will be turned into the converting chamber 3 (if it be a "bottom blow" converter as shown) and the furnace tilted toward the converter until it is nearly, but not quite, in the position shown in Fig. 2 of the drawings, and the molten metal will flow through the opening 2 into same. In about ten minutes this five ton mass of molten metal will be thoroughly decarbonized and desiliconized and incidentally its temperature raised from about 1800° F. to about 3000° F. Thus the converting department of my improved furnace accomplishes in a few minutes that which takes hours by the open hearth furnace, and with no other fuel than a blast of air. In addition to this great saving of time and expense, other most favorable conditions obtain—conditions non-existent in the straight open hearth practice. These are first, a highly acid slag develops during the act of blowing in the converter. This is removed by tilting the furnace farther in the same direction until the level of the surface of the metal reaches the lip or upper edge of the outer wall of the converter, as shown in Fig. 2, so as to allow the slag to drain off. The removal of the slag in this manner may be expedited by directing a blast of air from the mouth of the air passage 8 laterally across the surface of the metal. Thus the bath is freed from a large mass of highly acidulous and impure matter without interrupting the continued action of the furnace, an accomplishment impossible in the regular open hearth furnace. Second. As the furnace is tilted back to its normal position, this 5 tons of metal at a temperature of about 3000° F. flows back into the melting chamber, intermingling with the bath and materially raising the temperature of the entire mass and greatly hastening the liquefaction of the unmelted portion of the charge at a great saving of fuel. Third. This metal from the converter being thoroughly impregnated with oxidizing gases, due to the action of the air blown into it, the carbon in the bath will most eagerly combine therewith, acting exactly as iron ore does in the ordinary practice, thus effecting another saving in avoiding the use of iron ore as an oxidizing agent.

As the furnace has been made to tilt with the gas or fuel ports as an axis, the melting operation in the melting chamber has not been interrupted during the act of "blowing" and returning the "blown" mass to the parent bath. Dephosphorization, through the action of the lime slag has also gone on uninterruptedly, as it is a matter of common practice in the manufacture of even high carbon steel by the basic open hearth furnace, to remove phosphorus to a mere trace in the presence of high carbon. If a test is now made, and it shows "high" carbon, another five tons may be "blown" in a few minutes 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. This acid slag formed by "blowing" a small portion of the bath in the converting chamber is removed 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 hearth, if so desired, without injury to the basic lining owing to the presence of the lime slag. At the end of about two hours' time the entire charge will be melted, decarbonized, desiliconized, dephosphorized and brought to a very high temperature.

If the sulfur content could be disregarded in buying raw materials for use in connection with open hearth practice, much could be saved both in the purchase price of the material and in decreased loss of the finished product. While sulfur can possibly be eliminated or at least much reduced in the open hearth furnace, it is accomplished, if at all, only at the expense of much time, fuel, and expensive alloys, and the development of the steel makers' worst foe, viz. occluded gases, caused by the continued exposure of the bath to the fierce oxidizing influence of the fuel. As the electric furnace operates under non-oxidizing influences, it excels in the removal of sulfur and in deoxidizing, in fact it is the only really successful means known. It has been found in ordinary practice, when hot metal to be refined is served an electric furnace from the open hearth or converter, by far the greater per cent. of electrical energy is consumed in bringing the slag, metal and furnace to the proper high temperature, therefore if the metal, slag and furnace were brought to this necessary high temperature before the electric current was applied, the most economincal conditions possible would follow. Thus, when the bath has been properly decarbonized, desiliconized, dephosphorized and brought to a high temperature by my improved furnace in the manner heretofore described, the gates I are raised closing the gas ports, practically sealing the furnace. Then the electrodes are lowered into position and the current applied to the bath for about one hour, resulting in a bath of the highest grade of steel obtainable, made from low grade materials without regard to chemical content. The furnace is then tilted in the direction shown in Fig. 3 of the drawings, and the contents drawn off through the pouring spout J into a ladle ready for teeming. I do not confine myself to the production of steel from a cold charge, as "hot" or melted metal from the blast furnace, cupola or mixer can be introduced into the melting chamber of my furnace and the most satisfactory and economical results follow. Again as a very good grade of steel could be made without the aid of the electric current, I desire to be understood as claiming as my invention, the furnace as hereinbefore described, either with or without the electrical features described.

What I claim as new is:—

1. A metallurgical furnace comprising a melting chamber provided with gas or oil fuel melting means, a "blowing" chamber having communication with the melting chamber, and adjustable electrodes extending into said melting chamber.

2. A metallurgical furnace having an open hearth provided with fuel ports and communication with regenerative chamber, a blowing chamber communicating with the hearth, and adjustable electrodes extending into said hearth.

3. A metallurgical furnace of the open hearth type adapted to be tilted and comprising a melting chamber, and a "blowing" chamber communicating with the melting chamber, and adjustable electrodes extending into said melting chamber.

4. A metallurgical furnace of the open hearth type adapted to be tilted, comprising a melting chamber, a "blowing" chamber, fuel ports, and regenerating chamber flues having communication with the melting chamber, adjustable electrodes extending into said melting chamber, and means adapted to maintain operative communication between the melting chamber, the "blowing" chamber, fuel ports, and the regenerating chamber flues and the electrodes, whether the furnace is in a normal position, a tilted position, or during the period of being tilted.

5. A metallurgical furnace having an open hearth adapted to be tilted and provided with fuel ports and communication with regenerative chambers, and a "blowing" chamber communicating with the hearth and adjustable electrodes extending into said hearth, and means adapted to maintain operative communication between the hearth and the "blowing" chamber, the fuel ports, the regenerative chamber flues and the electrodes, whether the furnace is in a normal position, a tilted position, or during the period of being tilted.

6. A metallurgical furnace of the open hearth type comprising a melting chamber provided with means for electrically treating its contents, and a "blowing" chamber communicating with the melting chamber.

7. A metallurgical furnace of the open hearth type adapted to be tilted and comprising a melting chamber provided with means for electrically treating its contents and a "blowing" chamber communicating with the melting chamber.

8. A metallurgical furnace comprising a hearth provided with fuel ports, communication with regenerating chambers, also means for electrically treating the contents of the hearth, and a "blowing" chamber communicating with the hearth.

9. A metallurgical furnace of the open hearth type adapted to be tilted, comprising a melting chamber having a "blowing" chamber, fuel ports and regenerating chamber flues communicating therewith; and means for electrically treating the contents of the melting chamber, and means adapted to maintain operative communication between the melting chamber, the "blowing" chamber, fuel ports and the regenerative chamber flues whether the furnace is in a normal position, a tilted position, or during the period of being tilted.

10. A metallurgical furnace having a hearth adapted to be tilted and provided with fuel ports, communication with regenerating chambers, a "blowing" chamber communicating with the hearth, and means for electrically treating the contents of the hearth, and means adapted to maintain operative communication between the hearth, the "blowing" chamber, the fuel ports and the regenerating chamber flues whether the furnace is in a normal position, a tilted position, or during the period of being tilted.

11. A metallurgical furnace comprising a hearth, a blowing chamber communicating with said hearth, fuel and air ports communicating with said hearth, means adapted to close communication between the hearth and said fuel ports, means for tilting the furnace about the fuel ports as an axis and means for electrically treating the contents of the hearth.

12. A metallurgical furnace comprising a hearth, a blowing chamber having communication with the hearth and provided with an air blast slag removing means, means for tilting the furnace, and means for electrically treating the contents of the hearth.

13. A metallurgical furnace comprising a hearth, a converter removably attached thereto and which in its lower part communicates therewith, and means for electrically treating the contents of the hearth.

14. A metallurgical furnace comprising a hearth, a blowing chamber removably attached thereto and which in its lower part communicates therewith, means for electrically treating the contents of the hearth, and means for tilting the furnace.

15. A metallurgical furnace comprising a hearth, a removably attached blowing chamber communicating therewith, fuel ports at the ends of the hearth communicating with regenerative chambers, means for rocking the furnace about the fuel ports as an axis, and means for electrically treating the contents of the hearth.

16. A metallurgical furnace comprising a hearth, a removable blowing chamber exteriorly attached to one of the side walls and communication from the hearth to the blow-

ing chamber, charging doors and pouring spout located in the opposite side wall, end walls provided with fuel and air ports communicating with the hearth, means for tilting the furnace about the fuel ports as an axis, and means for electrically treating the contents of the hearth.

17. A metallurgical furnace comprising an open hearth, a removable blowing chamber attached to one of the side walls and having communication with the hearth, charging doors and pouring spout located in the opposite side wall, end walls provided with fuel ports communicating with the hearth, means adapted to close communication between the hearth and said fuel ports, means for tilting the furnace about the fuel ports as an axis, and means for electrically treating the contents of the hearth.

18. A metallurgical furnace of the open hearth type, comprising a melting chamber, a blowing chamber attached to one of the side walls and having communication with the hearth, air blast slag removing means in said wall, charging doors and pouring spout located in the opposite side wall, end walls provided with fuel ports communicating with the hearth, means adapted to close communication between the hearth and said fuel ports, means for tilting the furnace about the fuel ports as an axis, and means for electrically treating the contents of the hearth.

In witness whereof I have hereunto set my hand this 25th day of February 1911.

FRED B. LAMB.

Witnesses:

A. B. FRENIER,

F. M. GODDARD.