J. LUND.

METALLURGICAL APPARATUS.

APPLICATION FILED AUG. 8, 1918.

1,415,183.

Patented May 9, 1922.

2 SHEETS—SHEET 1.

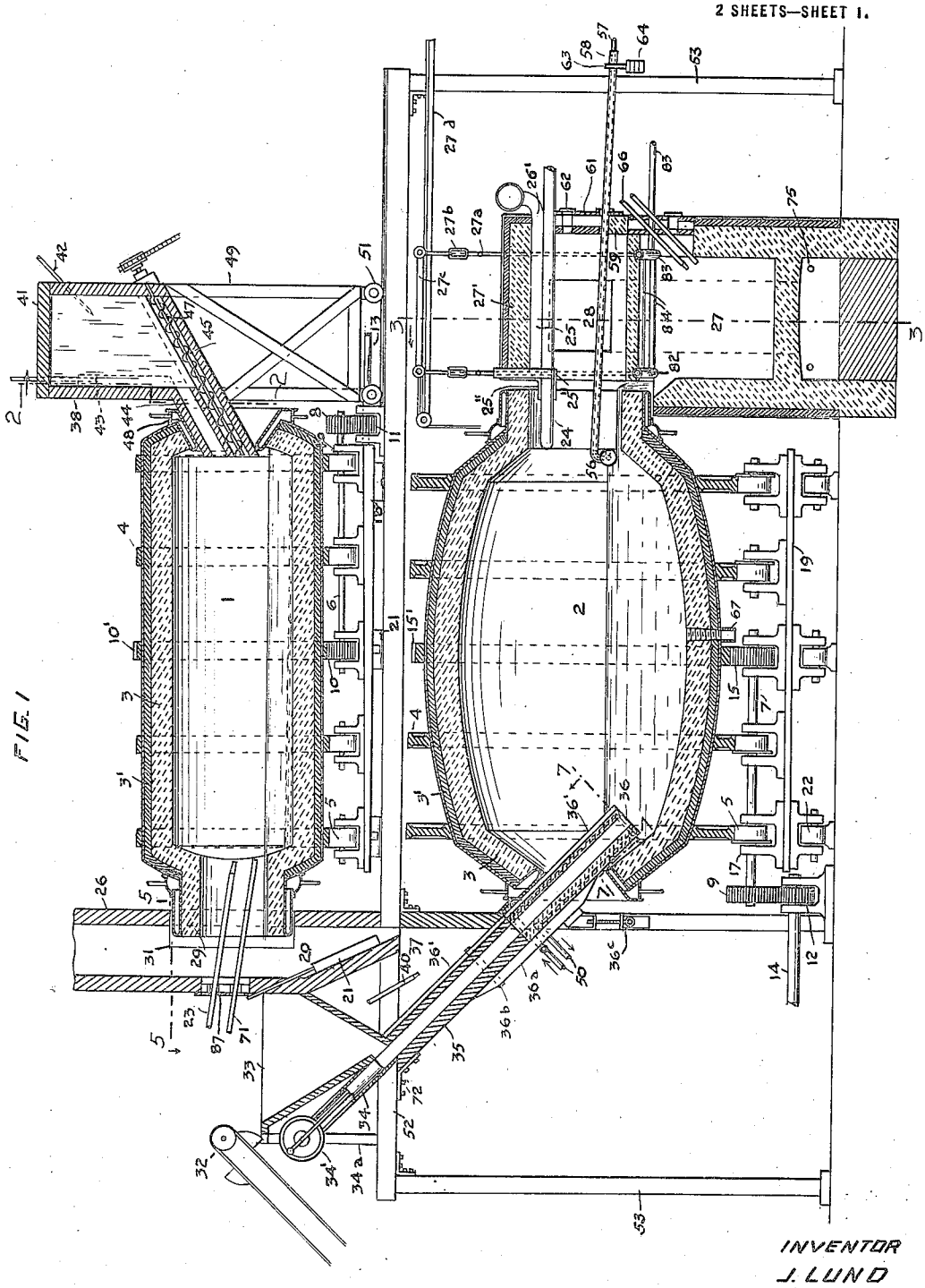


FIG. 1

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2 SHEETS—SHEET 2.

FIG. 2

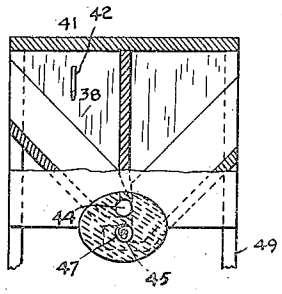


FIG. 7

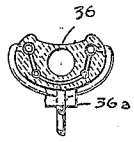


FIG. 3

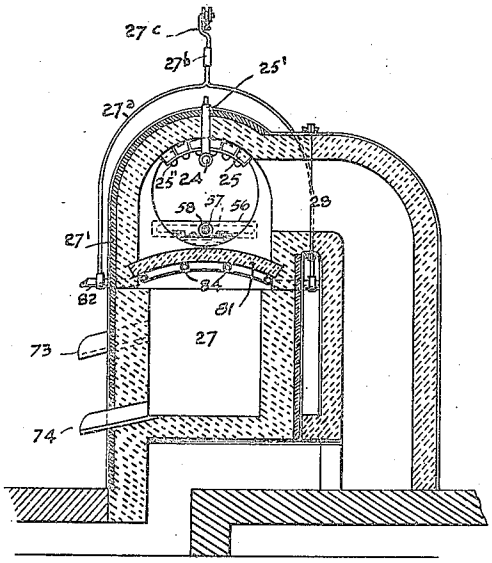


FIG. 6

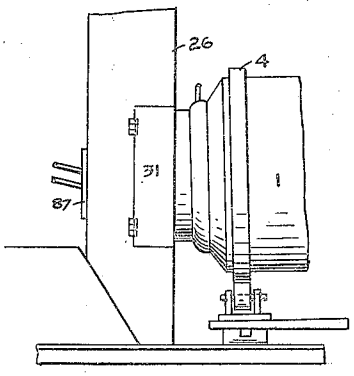


FIG. 4

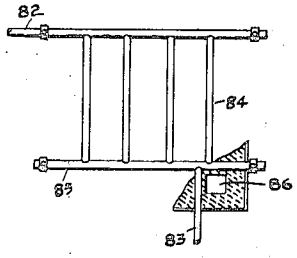
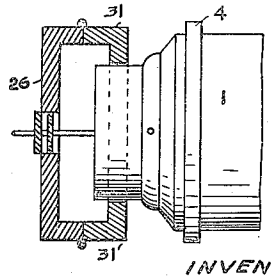


FIG. 5



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UNITED STATES PATENT OFFICE.

JOEL LUND, OF SAN FRANCISCO, CALIFORNIA.

METALLURGICAL APPARATUS.

1,415,183. Specification of Letters Patent. Patented May 9, 1922.

Application filed August 8, 1918. Serial No. 248,854.

To all whom it may concern:

Be it known that I, JOEL LUND, a citizen of the United States, residing at San Francisco, in the county of San Francisco and State of California, have invented new and useful Improvements in Metallurgical Apparatus, of which the following is a specification.

The object of the present invention is to provide an improved apparatus for smelting and refining metalliferous material and simultaneously refining the slag produced for repeated use.

In the accompanying drawings, Figure 1 is a longitudinal vertical section of my improved apparatus; Figures 2, 3, are transverse sections thereof on the lines 2—2 and 3—3 of Figure 1; Figure 4 is a broken sectional view showing a detail of Figure 3; Figure 5 is a horizontal sectional view on the line 5—5 of Figure 1; Figure 6 is a broken side view of an upper portion of the apparatus; Figure 7 is a sectional view on the line 7—7 of Figure 1.

Referring to the drawing, 1 indicates a slag furnace, and 2 a smelting furnace, the interior of each being lined with refractory slag-resistant material 3, between which and the wall of the furnace is preferably interposed asbestos or other heat-resistant material 3′. Said furnaces are formed on the outside each with a series of rings or wheels 4, which are supported by rollers 5 on shafts 6, 7, respectively, rotated by gear wheels 8, 9, respectively, meshing with gear wheels 11, 12, on shafts 13, 14, respectively, rotated from any suitable source of power. Said shafts 6, 7, carry gear wheels 10, 15, which mesh with gear rings 10′, 15′, around the furnaces 1, 2, respectively and thus positively rotate said furnaces about their axes.

Said shafts 8, 9, rotate in bearings 16, 17, which are supported by platforms 18, 19, which can move transversely on rollers 21, 22, so that, when desired, said furnaces can be moved in a direction transverse to their length.

The slag furnace 1 and the smelting furnace 2 are supplied with fluid, or pulverized solid, fuel by burners 23, 24 which enter the furnaces at one end thereof. The burner 24 is upheld by a hollow strap 25′ water-cooled by means of pipes 26^a and 26^b and is supplied with heated air by air pipes 25, protected from being oxidized by a coating of a silicate, or other insulating non-oxidizable material that has been melted thereon, such coating, however, being sufficiently thin to permit the air in said pipes to be heated by the heated gases escaping from the furnace to a flue 28. The protective cover of the air pipes 25 may be baked or melted or in any well known manner, or the pipes may be dipped in a molten silicate such as molten slag or the like.

Said pipes 25 are formed with outlet openings 25″, (Fig. 3). They are connected with a main blast pipe 26′. The products of combustion from the furnace 1, after circulating around the entire length of the furnace, escape by a chimney 26 at the same end of the burner 23. The products of combustion from the furnace 2, after likewise circulating around said furnace, escape at the burner end of the furnace, and pass into a settling chamber 27, in a side of which is the flue 28 which extends downwardly so that the hot gases can be utilized to keep the metal and slag thoroughly heated.

The connection between the furnace 1 and the chimney 26 is made by means of a comparatively narrow neck 29. To permit the slag furnace to be moved transversely after certain periods, to be substituted by another slag furnace, the sides of the chimney next to that through which the neck of the furnace enters are each cut away sufficiently to permit the neck to pass transversely through said sides, so that the neck of one slag furnace passes through one of said cutaway sides, while that of the other slag furnace passes through the opposite cutaway side. These cutaway sides are closed, when the furnace is in the proper position, by chimney sections 31.

When iron ore is to be smelted it is pulverized or comminuted, and is mixed with a proper amount of pulverized carbon and a small quantity of suitable flux and preferably ground with a solution of carbonate of an alkali metal, and the mixture is formed into briquettes of a preferably spherical form so as to facilitate the feeding of the same into the furnace after said briquettes are dried. The quantity of carbon which is so mixed with the ore determines the extent to which the metal is carburized in the process. By grinding the materials involved, in a suitable vessel in the presence of said alkaline solution, an intimate mixture of said

materials is obtained, thus promoting a rapid reduction of the same in the furnace. These briquettes are conveyed by an elevator 32 to a hopper 33 and transferred from said hopper, by means of a reciprocating piston 34, to an upper chute 35, continuous with a lower chute 36, communicating at its upper end with the hopper 33. The piston 34 and wheel 34′ for operating the same are detachable from their support 34ª when material in the form of bars form the charge to be fed into the furnace, and the piston 34 and wheel 34′ are then detached, since said bars are more conveniently fed into the opening filled by the piston. The tops of the chutes 35, 36, are trough-shaped, as shown at 36′. The chute 36, including the trough-shaped upper side 36′, is kept cooled by water conduits 50 therein. The chute 36 may be omitted and the chute 35 may be extended into contact with the liquid in the furnace 21. Into the hopper 37 is fed molten slag from the rotating furnace 1, said slag overflowing from said furnace into a conduit 20 controlled by a gate 21 and being supplied to said furnace 1 by means of a hopper 38. The charge and slag in the hopper 37 are heated by a burner 40. The slag is charged into the hopper 38 through the top which is afterwards closed by a shutter 41. Said slag is maintained hot in said hopper by means of a burner 42, and a gate 43 shown in dotted lines, since it is on the rear side of the partition between the two compartments of the hopper 38, limits the rate at which the slag is permitted to escape by a chute 44 from the hopper. A chute 45 is located beneath the hopper 38 and chute 44 and discharges into the furnace. Basic or acid material as may be found necessary to properly proportion the slag to render it more fluid and a more efficient fluxing agent is contained in the said chute 45 and hopper 37 and is conveyed as desired by means of a feed screw 47. The chute 44 discharges into the end of the rotating furnace 1 opposite to the burner 23, and the chutes 44 and 45 are maintained comparatively cool by means of a water jacket 48 therearound. Said hoppers are supported upon a suitable frame 49, which can be moved to and from the furnace 1 by means of rollers 51.

I provide, however, in the slag furnace 1 a bottom layer of molten iron, the depth of molten iron being sufficient only to cover the bottom of said rotating furnace and not to escape through its neck. The upper layer of slag escapes through the neck, leaving the iron permanently in the vessel.

The chute 35 removably depends from a platform 52 supported by standards 53 and is secured to said platform by screws 72. The chute 36 is attached to the chute 35 by a cradle 36ª and strap 36ᵇ and is additionally supported by an adjustable support 36ᶜ. When it is desired to move the furnace 2 transversely, the chute 35 is detached from the platform 52 and the lower chute 36, and the adjustable support 36ᶜ is lowered, so that the chute 36 extends horizontally into the furnace 2 and can thus be removed from the hole in the end of the furnace 2 through which it formerly projected. The upper part 27′ of the settling chamber 27, which is detachable from the lower part, is also removed, carrying with it the burners and air pipes. Said upper part 27′ is supported by straps 27ª having turn buckles 27ᵇ and depend from a carriage 27ᶜ travelling on a rail 27ᵈ.

By the chute 36 and trough 36′ the briquettes and slag are fed into the furnace 2 below the surface of the molten material therein. Said material consists of carburized molten metal and a layer of slag floating thereon. These are heated by the burner 24 which heats the upper part of the furnace 2 and the bath therein, and by reason of the rotation of said furnace, the heated upper portion is continually moved below the molten bath which is thereby also heated from underneath. The height of the layer is governed by the height of a cylindrical hollow slag dam 56 which is water-cooled by means of an inlet pipe 57 inclosed by an outlet pipe 58 (see drawing), said pipes extending through a groove or depression formed in the bottom of a hole in a wall 59 of said settling chamber which is closed by a door 61, said door having therein a mica window 62 and carrying the burner 24. Upon the outer end of the pipe 58 is a hanger 63 which supports weights 64, by adding to or subtracting from, by which the slag dam 56 may be raised or lowered correspondingly.

As the level of the slag rises in the furnace 2, the slag dam also rises, thus permitting metal to flow underneath the dam into the settling chamber. Since the effective weight of the slag dam is accurately counterbalanced by the weight of the counterweight, it results that any increase in thickness of the layer of slag will cause said slag dam to rise and permit a certain amount of slag, as well as metal, to flow beneath the slag dam. The metal settles to the bottom of the settling chamber, and to ensure such separation by gravity the liquids in the settling chamber are maintained hot by means of a burner 66 and by the heat of the bottom of the settling chamber. The metal is drawn off from time to time from the settling chamber by a tap hole 74 and the slag is then drawn off through a hole 73 and is elevated by suitable means and discharged into the slag hopper 38.

Before so drawing it off from the settling chamber the slag is purified by means of a blast of steam and air through a pipe 69.

The slag is further purified in the slag furnace 1 when needed by means of steam and air discharged through a pipe 71.

The steam is believed to purify the slag in the following manner. There is always a small quantity of metal contained in the slag, and this metal takes up the oxygen of the steam, thereby freeing its hydrogen, which combines with the sulphur in the slag.

At all junctures of open ends of the furnaces 1 and 2 with stationary parts, as the chimney 26, the chutes 44, 45, and 35, and the settling chamber 27, there is provided a water jacket 48 (see Figure 1) having a stationary wall 50 and a wall moving with the furnace and making a water-tight fit with the wall 50.

A roof 81 is provided to prevent gases entering the settling chamber from the furnace 2 if the apparatus is used as a refining furnace. To maintain the roof 81 comparatively cool, I provide water cooling pipes, of which 82 indicates the inlet pipe and 83 the outlet pipe, said pipes 82, 83, being connected by a series of transverse pipes 84. 86 indicates a conduit for carrying off gases from the settling furnace. When molten iron forms part of the charge, the door 87 in the chimney 26 is opened and the fluid iron from a blast furnace or mixer is poured through said opening by a suitable conduit, and it mixes with the slag in the flue in which said slag is carried down into the chamber and is decarburized by the oxygen of the ore or other oxidizing agents fed in suitable quantities into the furnace chamber by means of conduit 36.

In case solid metal is the main portion of the charge I preferably introduce it into the furnace by removing the detachable feed mechanism and feeding it through the chute in which said mechanism operates and I also feed proper portions of slag and qualifying agents.

As shown at 28 in Figure 3, the flue for the heating gases passes underneath the settling chamber and thereby maintains the liquid metal and slag in the settling chamber in a highly heated fluid condition, this being necessary in order to better facilitate the purifying of the slag. Additional burners 75 are provided in case the heat from the gases should not be sufficient.

The term "metalliferous" is intended to mean ores or metals either solid or molten.

The term "a charge" is intended to include the various materials which enter the liquid metallic bath under a molten or liquid cover. The liquid cover, or layer, herewithin mentioned, is not necessarily a slag at the commencement of the process, although its composition is similar to that of a purified slag, but acid and basic materials in proper proportions to form a silicate compound fusible at the temperature of the furnace may be melted down or provided from any suitable source.

Said "liquid cover" acts in practice as an absorbent of sulphur and phosphorus and since by its use it becomes contaminated with said impurities contained in the charge it may, after the commencement of the process, be properly called "a slag". This slag, however, needs to be purified and chemically qualified, as by the addition of acid and basic materials, or either of them alone, in order that it may be used repeatedly in the process.

Fluxes or mixtures already known to be used in smelting and refining to bring about certain results are introduced with, and form a part of, a charge and retain their advantages in my process, with this additional advantage, that the molten slag or liquid cover which continuously enter the furnace in a purified and chemically qualified condition also acts as an effective flux. In my application Serial No. 211,269, filed Jan. 10, 1918 I show the charge and slag conduits extending parallel on a horizontal plane into the furnace, and such construction may be used when molten metal forms the main part of the charge, and the conduit need not be extended into the molten bath, the slag fed upon the molten metal forming a protector therefor. Said conduits being removably attached to the platform, the change is readily made. When it is desirable to treat with only a limited amount of material at a time or that the metallic bath itself should be treated to form a finished product, my process is equally applicable in that I supply, maintain, and withdraw, to, on, and from the said bath, the repeatedly purified and qualified slag, which forms a protective cover thereon, and when there is not a sufficient quantity of the metallic bath in the furnace to cause the slag to overflow into the settling chamber, then the excess of slag covering said bath may be withdrawn by means of a hand rake through the door and opening, the slag dam being in such case removed, and the finished metal being withdrawn through tap hole 75.

It being well known in metallurgy that wet material submerged in a metallic bath will cause explosion, it is understood that all materials composing "a charge," and which are to be submerged in said bath, must previously have had the moisture expelled by any well-known means whether this be specifically stated or not.

When it is desirable to produce an unusually basic slag in furnace 1, to take up the sulphur and phosphorus from the metalliferous material in furnace 2, this is accomplished by adding basic material to the molten purified slag in furnace 1 by means of the hopper and feed mechanism, as shown, said basic material being melted down while

mixing with the molten slag in furnace 1. As such a composition requires high heat to melt and remain fluid it is desirable that most of the steaming of the slag be done in the settling chamber 27, as thereby the heat produced by combustion of fuel in the chamber 1 is utilized for smelting said basic material.

Oxidizing or carburizing materials or alloys acting in their well known capacities are also introduced with and form a charge or part of a charge, said material being added in suitable quantities to bring the metal to the nature desired.

When solid metal is the main part of a charge, said metal is preferably fed in suitable lengths into the metallic bath through the flue, the detachable feed mechanism being in such case removed.

Other solid ingredients which form the balance of said charge are fed simultaneously into said bath from the hopper through the conduit.

The nature of the charge and the uses to which the metal produced is to be put being known, by examining from time to time the molten metal overflowing into the settling chamber, the speed of feeding and the length of treatment necessary may be determined and also whether any well known modifications of the components of such charge are needed to facilitate the operation and attain the best results. When molten metal direct from the blast furnace or mixer constitutes the main portion of the charge, said metal is introduced through a door in the chimney 26 and is fed together with the purified slag into the metallic bath in furnace 2 by means of the slag spout.

I claim:—

1. In a metallurgical apparatus, a main chamber, means for permanently maintaining a metallic bath in said chamber, means for supplying, maintaining, and withdrawing a protective cover of molten slag on and from said bath, means for simultaneously feeding solid material and molten slag into said chamber, and means for applying heat from both above and below to the contents of the chamber.

2. In a metallurgical apparatus, a main chamber, a metallic bath in said chamber, means for supplying, maintaining and withdrawing a protective cover of purified molten slag on and from said bath, means for feeding a charge into said bath under said cover, means for internally heating said chamber, a settling chamber to receive the excess of the bath and slag, means in said chamber for forcing a purifying agent on to the products which overflow thereinto, means for heating the bath and slag in said settling chamber from both above and below, means for preventing exhaust gases from the main chamber entering the settling chamber, means whereby the gas generated in said settling chamber may escape, and means for the separate withdrawal of slag and metal from said settling chamber.

3. In a metallurgical apparatus, a main chamber, means for permanently maintaining a metallic bath in said chamber, means for constantly supplying, maintaining and withdrawing a protective cover of purified molten slag on and from said bath, means for feeding a charge into said bath under said cover, means for applying heat from above and below to the contents of said chamber, a settling chamber to receive the excess of the bath and slag, means in said settling chamber for forcing a purifying agent on to the products which overflow thereinto, means for heating the bath and slag in said settling chamber from both above and below, a removable cover to prevent exhaust gases from the main chamber coming in contact with the metal in the settling chamber, means for cooling said cover, said settling chamber having a removable upper portion, means for supporting and guiding said portion while it is being moved, and means removably attached to said upper portion whereby exhaust gases from the main chamber are guided under the hearth of said settling chamber.

4. In a metallurgical apparatus, a main chamber, a settling chamber, a slag chamber, and a slag reservoir, all so arranged that molten slag can flow by gravity from said reservoir through said slag chamber and main chamber into said settling chamber, means for maintaining said slag in a hot molten condition in said reservoir, and means for heating said slag in transit.

5. In a metallurgical apparatus, a main chamber, means for maintaining a metallic bath in said chamber, means for feeding a charge into said bath, means for constantly moving, supplying, maintaining, and withdrawing a protective cover of molten slag on and from said bath, means for heating the contents of said chamber from above and below, and means for emptying the chamber.

6. In a metallurgical apparatus, a main chamber, means for maintaining a metallic bath in said chamber, means for feeding a charge into said bath, means for constantly moving, supplying, maintaining, and withdrawing a protective cover of molten slag on and from said bath, means for heating the contents of the chamber from above and below, means whereby the thickness of said slag cover is automatically regulated, consisting of a counter-weighted slag dam, means for cooling said dam, and means for emptying the chamber.

7. In a metallurgical apparatus, a main chamber, means to rotate said chamber, means for maintaining a metallic bath in

said chamber, means for internally heating said chamber, separate conduits for feeding solid and molten material into said bath under a cover of slag, means for supplying, maintaining, and withdrawing said cover, means for regulating the flow of said material, means for cooling said conduits, and means for emptying said chamber.

8. In a metallurgical apparatus, a main chamber, means to rotate said chamber, means for maintaining a metallic bath in said chamber, means for supplying, maintaining, and withdrawing a cover of molten purified slag on and from said bath, means for internally heating said chamber, means for feeding a charge into said bath under said cover, means for receiving the excess of said bath and slag, comprising a settling chamber, means for forcing a purifying agent on to the material in said settling chamber, means for heating the material in said settling chamber from above and below, means for further purifying and qualifying said slag, comprising a slag chamber, located so that molten material may flow by gravity from the same into the main chamber, means in said chamber for maintaining a metallic bath, means for rotating the chamber, means for internally heating said chamber, means for forcing a purifying agent on to the slag in said chamber, means for causing the fuel and products of combustion to enter and exhaust through the same end of said chamber, means for feeding solid and molten material into said chamber and means for regulating the flow of said material.

9. In a metallurgical apparatus, a main chamber, and a slag chamber so placed that molten material may flow by gravity from said slag chamber into the main chamber, means for maintaining a metallic bath in said chambers, means for rotating the same, means for internally heating said chambers, means for causing the gases generated in said chambers to completely circulate within the same, means for feeding solid and molten material into said chambers, means for guiding the molten slag from said slag chamber into said main chamber, means for conducting away products of combustion, comprising a flue through one side of which said slag furnace enters, means in said flue wherethrough the interior of the slag chamber may be seen, and means for emptying said chambers.

10. In a metallurgical apparatus, a main chamber and a slag chamber, means for maintaining metallic baths in said chambers, means for internally heating the same, means for rotating said chambers, means for supplying, maintaining and withdrawing a cover of molten slag on and from the baths in said chambers, means for purifying said molten slag as it flows through the slag chamber, means for guiding the molten slag as it flows from said slag chamber into the main chamber, means for heating the slag in transit, means for feeding molten slag and solid material into said slag chamber comprising a movable reservoir divided into compartments, conduits from said compartments, wherethrough the molten slag and granulated material may be fed, the former immediately above the latter, into said slag chamber, and means for regulating the flow of said slag and material.

11. In a metallurgical apparatus, a main chamber, means for permanently maintaining a metallic bath in said chamber, a burner in said main chamber for heating said bath, means for blowing into said chamber air for combustion of the fuel from said burner, means for circulating the products of combustion entirely around the interior of the said main chamber, means for heating said air for combustion, comprising a removable portion of, and over, a settling chamber, means in said removable portion for conducting said air for combustion through the same into said main chamber, and means for causing said products of combustion to pass in close proximity to said air conducting means in said removable portion of said settling chamber.

12. In a metallurgical apparatus, a main chamber, means for permanently maintaining a metallic bath in said chamber, means for supplying, maintaining, and withdrawing a protective cover of purified molten slag on and from said bath, means for feeding solid and liquid material into said bath, comprising supports adjacent to said main chamber, a conduit removably attached to said supports, and a piston reciprocating in the conduit and removably attached to others of said supports adjacent thereto, means for regulating the flow of material into said main chamber, and means for applying heat from above and below to the contents of the chamber.

13. In a metallurgical apparatus, a main chamber, a stationary platform over said chamber, a movable slag chamber supported by said platform, means supported by said platform for conducting solid and molten material into said chambers, means for preventing the escape of gases through the feed end of said chambers, means supported by said platform for receiving solid materials comprising an elevator and a hopper, means in the bottom of said hopper to permit said material to escape, comprising a contracted end of said hopper, opening into said conducting means, means immediately back of said opening for forcing said material into said main chamber, means for maintaining metallic baths in said chambers, means for supplying, maintaining, and withdrawing molten slag on and from said baths, means

for purifying said slag in transit, means for heating the interior of said chambers, and means for rotating the same.

14. In a metallurgical apparatus, a main chamber, a platform over the same, a slag chamber supported by said platform, means for maintaining metallic baths in said chambers, means between said chambers for conducting molten slag by gravity from the slag chamber into the main chamber, means for purifying and heating the slag in said slag chamber, means for adding qualifying material to said slag, means for feeding molten slag into said slag chamber, comprising a slag reservoir, means for maintaining said slag in a hot molten condition in said reservoir, means for feeding a charge into the bath in the main chamber, means for maintaining and withdrawing a cover of molten slag of predetermined thickness over the bath in said main chamber, means for internally heating said chamber, and means for emptying the chamber.

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