No. 817,989. PATENTED APR. 17, 1906.

A. M. ROBESON & C. A. BETTINGTON.

FURNACE FOR BURNING PULVERIZED FUEL AND OTHER SUBSTANCES.

APPLICATION FILED APR 13, 1905.

4 SHEETS—SHEET 1.

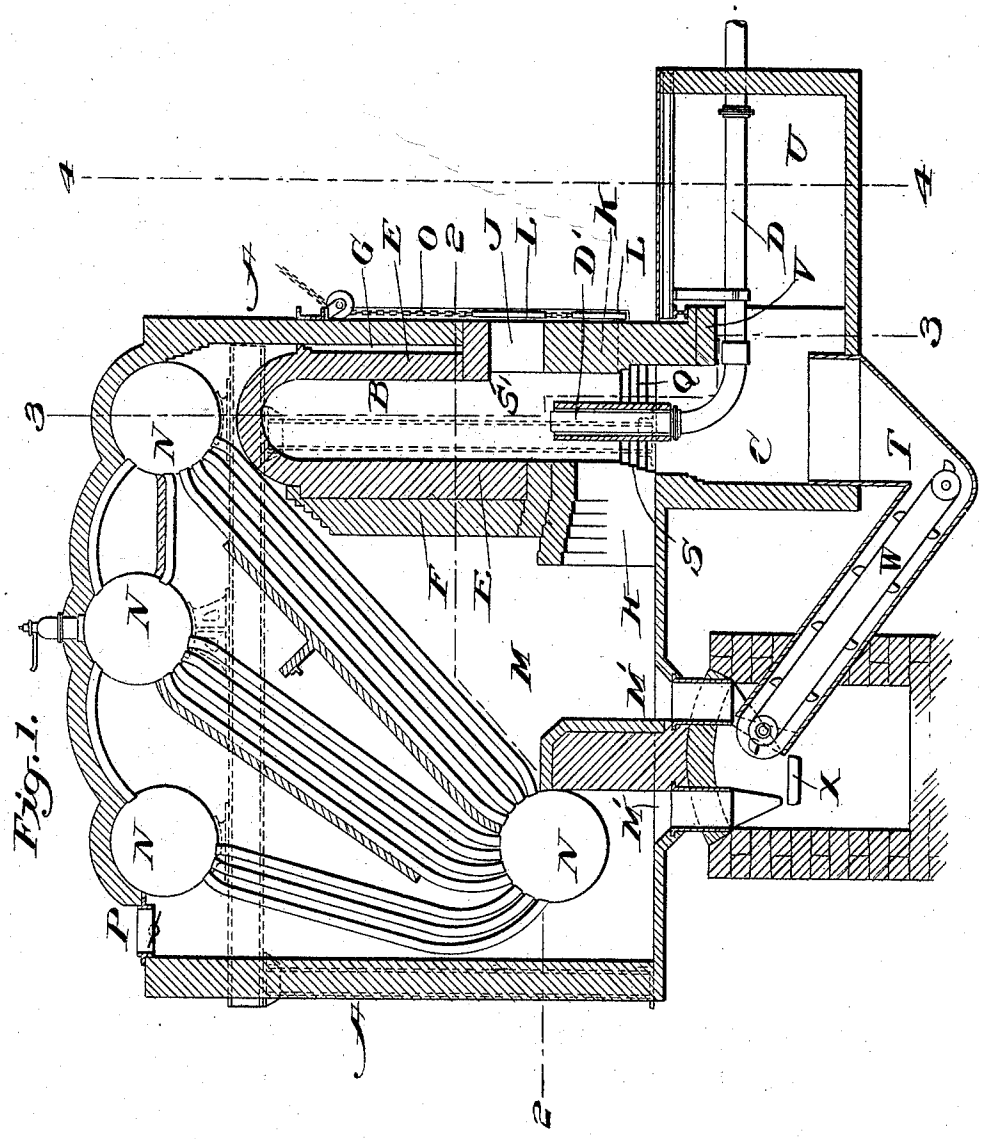


Fig. 1.

Witnesses
Allan Goose.
F. P. Richards.

Inventors
A. M. Robeson and C. A. Bettington
By their Attorneys
Seymour, Seymour & Seymour

No. 817,989. PATENTED APR. 17, 1906.

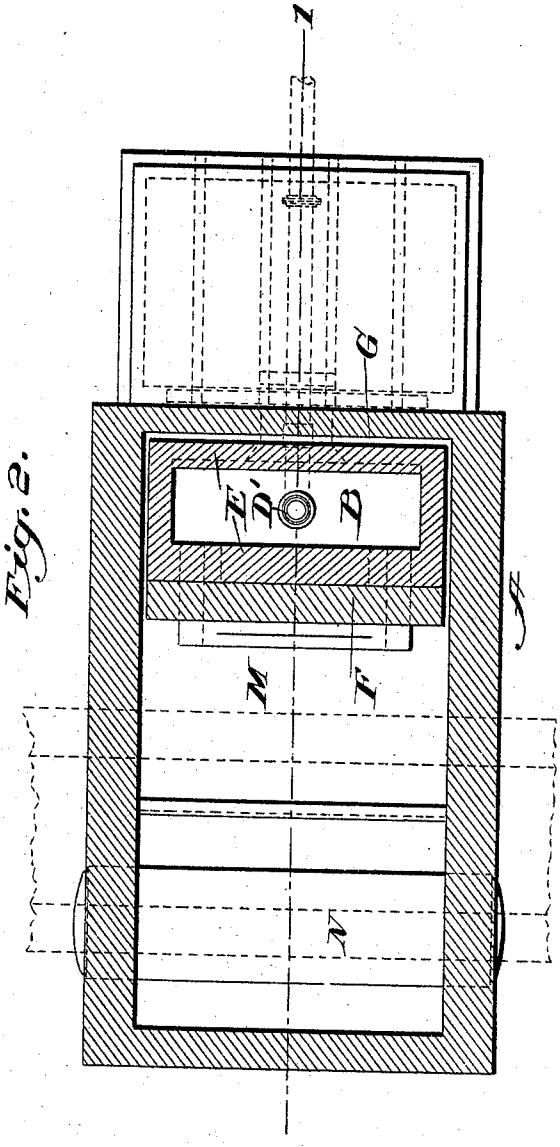
A. M. ROBESON & C. A. BETTINGTON.

FURNACE FOR BURNING PULVERIZED FUEL AND OTHER SUBSTANCES.

APPLICATION FILED APR 13, 1905.

4 SHEETS—SHEET 2.

Fig. 2.



Witnesses

Alexander Gross.

L. P. Richards

Inventors

A. M. Robeson and C. A. Bettington

By their Attorneys

Seymour, Seymour & Naylor

No. 817,989. PATENTED APR. 17, 1906.

A. M. ROBESON & C. A. BETTINGTON.

FURNACE FOR BURNING PULVERIZED FUEL AND OTHER SUBSTANCES.

APPLICATION FILED APR 13, 1905.

4 SHEETS—SHEET 3.

Fig. 4.

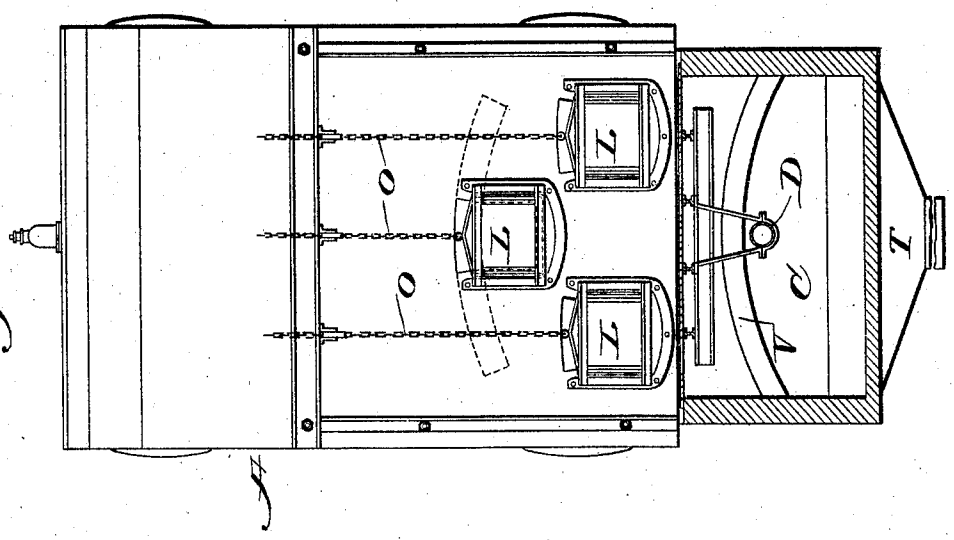
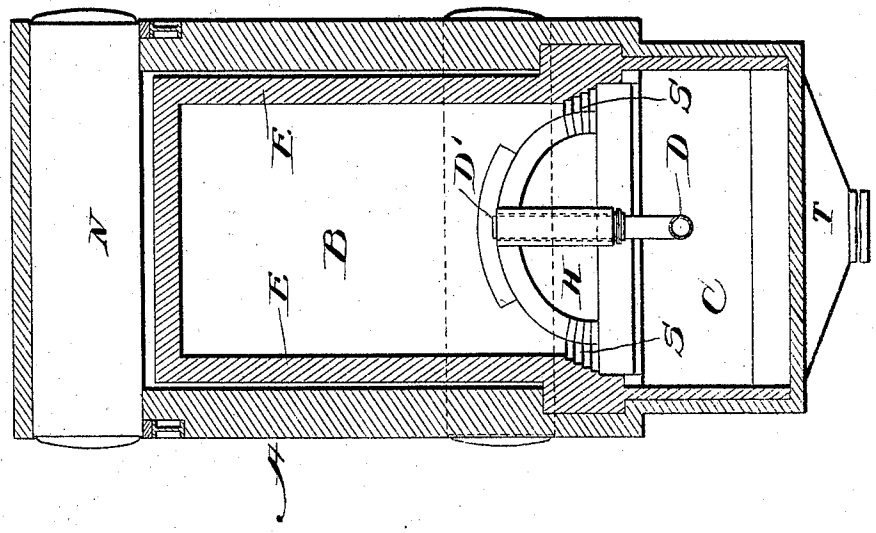


Fig. 3.



Witnesses

Allan Groose.

S. P. Richards

Inventors

A. M. Robeson and C. A. Bettington

By their Attorneys

Seymour, Seymour & Sheppard

No. 817,989. PATENTED APR. 17, 1906.

A. M. ROBESON & C. A. BETTINGTON.

FURNACE FOR BURNING PULVERIZED FUEL AND OTHER SUBSTANCES.

APPLICATION FILED APR 13, 1905.

4 SHEETS—SHEET 4.

Fig. 6.

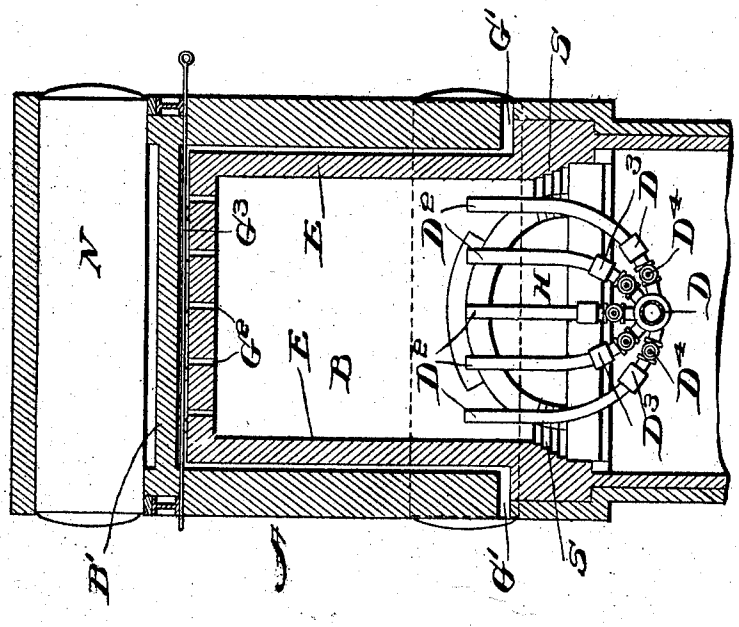
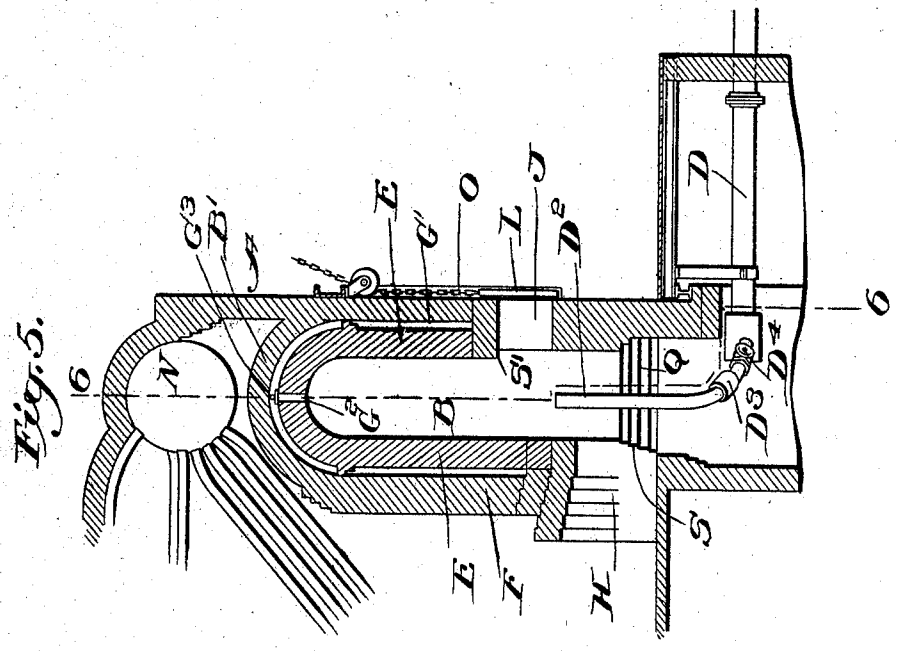


Fig. 5.



Witnesses

Allan Groose.

F. R. Richards

Inventors

A. M. Robeson and C. A. Bettington

By their Attorneys

Seymour, Seymour & Mapes

UNITED STATES PATENT OFFICE.

ANTHONY M. ROBESON, OF JOHANNESBURG, TRANSVAAL, AND CLAUDE A. BETTINGTON, OF BOSTON, MASSACHUSETTS.

FURNACE FOR BURNING PULVERIZED FUEL AND OTHER SUBSTANCES.

No. 817,989. Specification of Letters Patent. Patented April 17, 1906.

Application filed April 13, 1905. Serial No. 255,470.

To all whom it may concern:

Be it known that we, ANTHONY M. ROBESON, residing at Johannesburg, Transvaal, and CLAUDE A. BETTINGTON, residing at Boston, in the county of Suffolk, State of Massachusetts, have invented certain new and useful Improvements in Furnaces for Burning Pulverized Fuel or other Substances, of which the following is a full, clear, and exact description, such as will enable others skilled in the art to which it appertains to make and use the same.

Our invention relates to certain new and useful improvements in furnaces for burning pulverized fuel and other substances.

One of the objects of the invention is to so construct a furnace that the products of combustion and unconsumed fuel will double back upon themselves before escaping from the retort of the furnace.

Another object is to construct a furnace so that the retort will extend in an upward direction and be provided with means for projecting the material to be burned into the retort in an upward direction.

Another object is to so construct a furnace that the slag and unconsumed products will fall directly out of the retort of the furnace and into a pit or other means for receiving the same.

Another object is to construct a furnace so that the slag and other unconsumed products will fall from the retort into a pit and be conveyed therefrom.

Other objects will appear from the hereinafter description.

It is a well-known fact that when coal or other material pulverized or reduced to a fine powder is introduced into a furnace with the proper amount of air combustion is practically perfect, provided the fuel supplied, the quality of the fuel, and the air-supply remain constant within narrow limits; but when any of these features change either the fire goes out or it burns very inefficiently. We have experimented with many forms of furnaces on a working scale for burning powdered fuel and other material and find that while one form may answer well for one kind of material it will be found unsuitable for another. Furnaces which have been heretofore constructed for burning coal with three or four per cent. of ash, which makes no clinkers, clog up and are inoperative in a short time if fed with coal containing as high as twenty per cent. of ash. Furnaces which have heretofore been constructed having a given cross-section will possess a certain critical capacity which if exceeded in even the slightest degree results in the point of combustion gradually creeping in the direction of the flow of the gases and finally going out. This is a common fault of a furnace using powdered coal or other material in which the course of the gas is not directly back on itself during combustion and is due to the fact that the mixture of the powdered fuel and other material and air is really of an explosive nature, having a definite but slow rate of transmission of the point of explosion or combustion. The point of combustion commences to creep forward the moment the speed with which the mixture of air and fuel introduced into the furnace exceeds that of the rate of transmission of the point of explosion, the result being that the flame soon blows out. The rate of transmission of the point of explosion depends on the inflammability of the dust and the temperature of the mixture. No practical control can be had over the inflammability if any kind of coal is to be burned, and therefore it remains that the temperature of the mixture and its velocity only can be varied in order to make the point of explosion stable.

By causing the mixture to turn upon itself and return alongside of the incoming stream or separate and return along two sides of it or spread out in a circular or mushroom form and return on all sides, as would be the case if the retort were vertical and circular and the incoming stream central, not only is a regenerative action secured, which in itself would insure the point of explosion being close to the point of entrance to the furnace of the explosive mixture, but the very act of changing the direction of the flow of the gases changes the velocity of portions of the stream and at the turning-point by producing eddies, especially if the form of the furnace is unsymmetrical as regards ideal flow-lines, and thereby brings about the condition of decreasing velocity coincident with increasing temperature, thus creating a very stable condition.

After many experiments we have discovered that the vertical form of furnace is very efficient for carrying out our invention and is

the one we prefer if fuel or other material which produces slag while being burned is to be used; but the principle of making the products of combustion and the unconsumed material return or double back upon themselves for the purpose of controlling the point of combustion can be applied to a horizontal or inclined furnace, perhaps to greater advantage for certain services than to a vertical furnace. Therefore we do not confine ourselves to any particular form of furnace.

As before stated, for certain kinds of fuel or other material—namely, those containing over four per cent. of a slag-forming ash—a form of furnace, if powdered material is to be burned, which will rid itself of the accumulations of slag, is imperative. We have experimented with many devices and forms of furnaces to attain this object and find the furnace which we will hereinafter describe to be very efficient for this purpose. The slag which it is desired to remove from the furnace is liquid at the normal working temperature of the combustion-chamber or retort, but becomes viscous whenever it reaches a place where, for any reason, there is a lower temperature. Also, the slag which causes trouble is that which impinges on the walls of the retort and runs down them and not that which remains in suspension in and is carried along with the products of combustion. These suspended particles soon cool off enough after leaving the retort to render them incapable of sticking to surfaces, and therefore finally settle down with the dust-ash and give no further trouble.

The vertical form of furnace lends itself best to the disposal of slag for two reasons: (*a*) The area of a horizontal section of the vertical retort being always much smaller than that of a horizontal furnace of the same output, the radiation of heat into the slag-pit, which must be directly under the peripheral walls of the retort, will be much less in the vertical form, thereby allowing the deposited slag to become colder and render the operation of removing it less trying to workmen. (*b*) The particles of slag which are carried along with the products of combustion are moving in a downward direction toward the slag-pit just before leaving the combustion-chamber, and being relatively heavy and of a globular form instead of making a turn of ninety degrees into a horizontal direction along with the gases and dust they continue their rectilinear direction and project themselves into the slag-pit. It is these considerations that make the vertical form of furnace preferable to the horizontal for coals containing large quantities of slag; but all of the principles on which we base our invention can be applied to horizontal or inclined furnaces.

The preferred type of our invention is illustrated in the accompanying drawings, which form a part of this application, in which the same reference characters refer to similar parts in the different views.

Figure 1 is a horizontal section of the furnace, taken on the line 1 of Fig. 2. Fig. 2 is a horizontal section on the line 2 2 of Fig. 1. Fig. 3 is a vertical cross-section on the line 3 3 of Fig. 1. Fig. 4 is a vertical cross-section on the line 4 4 of Fig. 1. Fig. 5 is a cross-section of the modification. Fig. 6 is cross-section of the said modification, taken on the line 6 6 of Fig. 5.

The part lettered A on the drawings represents the outer walls of the furnace.

B is the combustion-chamber or retort.

C is a slag-pit immediately below the retort.

D represents a pipe for introducing into the retort pulverized coal or other material to be burned and mixed with air. The end of this pipe D′ is turned upward and projects upwardly into the retort. This end of the pipe which projects into the retort may be covered with some refractory material, or it may be water-jacketed.

The retort has its walls E formed of a refractory material, owing to the intense heat produced within it, and it should be made so as to permit free expansion, especially in a vertical direction. It is also surrounded on three sides by the walls F of the boiler-setting, which are preferably kept at a short distance from the walls of the retort in order to form an air-space G to lessen heat radiation.

In the furnace here shown the horizontal section of the retort is rectangular; but it may be made in any other form which the circumstances of the case demand. The top of the retort is arched with fire-brick; but it may be formed of flat refractory material and could be closed by means of a water-jacketed metallic cover, if desired.

At the bottom of the retort on one side is an opening H for the escape of the products of combustion. This opening is in the form of a single arch in one of the long sides of the retort; but it may be formed of more than one arch, or it could be formed in one or both of the short ends of the retort, the essential thing being that the outlets shall be as low down in the retort as possible, so that the time of combustion may be as long as possible for a given height of retort and the products of combustion be caused to double back upon themselves. The height of the retort should be such as to insure a sufficient combustion of all the combustible particles of the material fed into the retort before they are permitted to escape.

On the side of the retort opposite the opening H are the cleaning-openings J and an opening K, which is made use of for igniting the fuel and as an inspection-door. The covers L of these doors are made, preferably, of slabs of refractory material suspended by

bands to which is attached a counterbalance chain or rope O, arranged so that the doors may be conveniently lifted. These openings may be placed in a different position to that here shown or could be entirely dispensed with.

M is the boiler-chamber in which the boilers N are set. M′ represents openings in the floor or bottom of this chamber for the escape or removal of ash or other unconsumed material which escapes from the retort with the products of combustion in the form of dust.

P is an opening leading from the boiler-chamber and through which the products of combustion finally escape after passing through or around the boilers.

The bottom Q of the retort is open throughout its whole section and communicates with the slag-pit C, this construction being necessary when material of a slag-forming nature is burned. The bottom of the retort may be closed if material which does not form slag is burned. This form of retort is such that it permits the slag formed therein to escape therefrom in a very effective and simple manner. In furnaces heretofore constructed and when certain materials were burned the disposition of the slag was a very serious matter. The slag at high temperature is very liquid and runs readily down the brickwork or lining of the furnace or retort and forms a protective covering over the same and has been hard to remove therefrom. If the inner walls of the retort be formed so that they will come within the inner walls of the slag-pit and also be shown as stepped or projected inwardly, as indicated at S and S′, the slag will have a free fall. That part of the slag which forms against the inner wall of the retort can be melted off or allowed to grow at will by simply decreasing or increasing the rate of combustion. The slag drops freely into the slag-pit from the retort in this construction. The slag-pit may have a water-tray in the bottom thereof or be provided with a water-receptacle T, fitting directly under the lower end of the retort. The slag will be removed from this pit through the enlarged portion U. This pit may be provided with an arch V to protect the workmen in the enlarged portion from the direct radiation from the heat of the retort. The water-receptacle may be provided with an endless carrier W, moving in the water and extending up under the opening M′ in the floor of the boiler-chamber. This construction permits the slag or other material which drops from the retort into the pit and the dust which escapes from the said opening M′ to be removed by the same apparatus.

X is a carrier moving at right angles to the endless conveyer and on which the slag and dust is dumped and removed from the furnace.

If the furnace is used for burning pyritic ore in a fine state of division or for smelting purposes, the slag will be caught in suitable slag-cars, which, being on wheels, would be readily removed. If the ore being roasted or smelted does not readily form slag and if a slag product or matte be desired, suitable pulverized fluxes may be added to the mixture of coal and ore, and the character of the flame either oxidizing, neutral, or reducing, can be regulated so as to produce the desired result.

The overhanging part S of the retort might be differently placed without departing from our invention, the essential feature being to so construct the retort as to permit the slag which does not form on the retort to fall within the pit and that which clogs on the walls to run down and drip into the pit without causing trouble, as has been the case in furnaces heretofore constructed.

In the modification shown in Figs. 5 and 6 we extend the air-space surrounding the retort over the top thereof by making a second arch B′, which has the double advantage of forming a cold-air jacket for the retort instead of the hot-air gases of combustion. We also extend this air-space through the walls of the retort to the outer air, as shown at the point marked G′. We also provide the top of the retort with one or more openings G^2, so that air entering G′ and passing up through the air-passage G may be admitted into the interior of the retort through said openings. We also provide a damper or other means, G^3, for regulating the amount of cold air admitted into the retort. We have shown this damper at the top of the retort and adapted to control the openings G^2; but it is apparent that said damper may be placed at other points in the furnace—for example, at the inlet-openings G′. In Figs. 5 and 6 we have shown also a modified construction of pipe for admitting the powdered material to the retort. Instead of using one pipe, as shown in the other forms, the pipe D may be provided with a series of branch pipes D^2. Each of these pipes is constructed so as to be detachable at the joint D^3 and is provided with a valve D^4. This construction is used when working under light loads. Under these circumstances one or more of the pipes may be cut out. The use of several pipes would give greater elasticity to the system and at the same time give a more even distribution of the heat in the retort when working at full load. When any one of the pipes are not used, it may be advisable to remove it on account of the intense heat in the retort, which may injure the pipe when material to be burned is not being passed through it.

The material to be burned, or where metallurgical processes are involved, the fuel ore and fluxes are ground, preferably together, in any suitable fine-grinding machine, which can be of a type which combines a means of

producing an air-blast with a pulverizing-machine, thereby blowing the powdered material directly into the retort as fast as produced, or it may be of a form which delivers the pulverized material without an air-blast, in which case the pulverized material is blown into the furnace through the medium of any air-blast-producing apparatus into which is fed the pulverized material by means of any suitable feeder, suitable means being provided to vary the proportions of the air and pulverized material delivered to the furnace. In supplying the air instead of forcing it through the pipe D with pulverized material the air may be mixed with the material as it is projected from the upper end D′ of the pipe, suitable means being provided for introducing the air separate from the fuel at this point.

The method of operating the furnace is as follows: In starting the furnace a brazier filled with wood and greasy waste is introduced through the hole H and lighted. The brazier is formed so as to allow of a moderately-free passage of the powdered fuel through it when placed over the end D′ of the fuel-supply pipe. The blast is then started at a very low rate, and the material is fed into the retort at such a rate as not to smother the fire in the brazier. The powdered material immediately partially ignites and gradually heats up the retort. In a short time the retort is sufficiently hot to allow of the removal of the brazier, after which the rate of combustion will be increased until working conditions are reached. While we have here stated that the brazier is passed through the opening H to start the fire, yet it is understood that it may be started in any other manner, as the starting material may be passed into the retort through the opening at the bottom thereof. After the retort has been thoroughly heated the material to be burned may be varied at will without there being the slightest tendency on the part of the fire to go out, or the air and material supply can be completely cut off for a considerable time, provided the doors and drafts be closed, and the furnace then be started up in a short time by simply renewing the material and air-supply. It is preferable to so regulate the drafts of the furnace as to make the pressure within the retort about the same as that of the atmosphere to avoid loss of heat through infiltration of air; but if for any reason it is desired to have the pressure within the furnace greater or less than that of the atmosphere the furnace will work equally well. After the fire is started in the retort the products of combustion and the burning material are projected upwardly in the retort until they reach a certain point, which varies according to the force with which the material is injected into the retort, and other conditions, whereupon the products of combustion and the ignited material will fall downward or double back upon themselves. The products of combustion will pass out through the opening H into the boiler-chamber and circulate around the boiler-tubes and pass out through the opening P. The solid particles of unconsumed material, such as slag and other substances, will fall through the bottom of the retort and into the slag-pit. If any of the liquid slag falls up against the inner walls of the retort, it will trickle down the sides thereof and, owing to the construction of the bottom of the retort, as shown at S, and the sides, as shown at S′, will also drop down into the slag-pit. If the slag-pit is provided with a water-receptacle, such as shown, the slag will fall into the water in the said receptacle. The endless conveyer W being operated will remove the slag from the receptacle or the pit and throw it onto the carrier X. Any of the ash or solid materials carried from the retort into the boiler-chamber will fall on the floor of the boiler-chamber and can be thrown out through the openings M′ in the bottom of said chamber and into the carrier, the carrier operating to remove or convey both the slag from the slag-pit and the ash from the boiler-chamber in the construction shown.

Of course it is to be understood that if the endless carrier is not used for removing the slag the said slag may be removed through the extended portion U of the slag-pit in a manner well known.

As many changes could be made in the above construction and many apparently widely-different embodiments of our invention could be made without departing from the scope thereof, we intend that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense. We desire it also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention, which as a matter of language might be said to fall therebetween.

Having now described our invention, what we claim as new, and desire to secure by Letters Patent, is—

1. In a furnace, a combustion-chamber closed, except at or near the bottom thereof and means for injecting a finely-divided solid fuel and a supporter of combustion substantially vertically into the chamber, the open part of the chamber permitting the escape of products of combustion.

2. In a furnace, a combustion-chamber closed except at or near the bottom and means for injecting a mixture of fuel and a supporter of combustion substantially verti-

cally into the chamber, the open part of the chamber permitting the escape of products of combustion and unconsumed material.

3. In a furnace, a combustion-chamber, means for injecting finely-divided solid fuel substantially vertically into the chamber in one direction, said chamber having an exit adjacent to the point where the fuel is injected, whereby the products of combustion and unconsumed fuel are caused to double back in the combustion-chamber before passing from the chamber.

4. In a furnace, a combustion-chamber, a pipe through which pulverulent fuel is injected substantially vertically in one direction into the chamber, said chamber having an exit therein adjacent to the end of the pipe whereby the products of combustion are caused to double back in the combustion-chamber before passing therefrom.

5. In a furnace, a combustion-chamber closed except at or near the bottom thereof, a pipe or nozzle at the bottom of the chamber adjacent to the opening from the chamber, through which finely-divided solid fuel is projected substantially vertically into the chamber, the opening from the chamber permitting the escape of products of combustion.

6. In a furnace, a vertical combustion-chamber closed except at or near the bottom, means for supplying to the combustion-chamber fuel and a supporter of combustion, said means being so arranged with respect to the combustion-chamber as to cause at least some of the burning fuel to be supported or held in suspense by the incoming material.

7. In a furnace, a combustion-chamber, and a single means for supplying to the combustion-chamber a mixture of fuel and a supporter of combustion, said means being so arranged with respect to the combustion-chamber as to cause the fuel burning in the chamber to be supported and held in suspense by the incoming material.

8. In a furnace, a combustion-chamber having an opening near its lower end for the passage of products of combustion and another opening adjacent thereto for the passage of unconsumed products, and means for injecting material to be burned into the combustion-chamber so arranged as to keep the material in suspense while burning.

9. In a furnace, a combustion-chamber having an opening near the lower end thereof for the passage of products of combustion and another opening for the passage of unconsumed material and means for injecting material to be burned upwardly into the combustion-chamber.

10. In a furnace, a combustion-chamber open at or near the bottom thereof for the passage of products of combustion and unconsumed material, a pit under the combustion-chamber the inner surface of the walls of the combustion-chamber overhanging the walls of the pit and means for injecting the material upwardly into the combustion-chamber.

11. In a furnace, a combustion-chamber, open at the bottom thereof to permit the passage of unconsumed material, the said combustion-chamber having an opening near the bottom thereof for the passage of products of combustion, a pit under the combustion-chamber, the inner surface of the walls of the combustion-chamber overhanging the inner surface of the walls of the pit, and means for injecting pulverulent material upwardly into the combustion-chamber.

12. In a furnace, a combustion-chamber having an opening for the passage of products of combustion, a pipe near said opening and through which a pulverulent material may be injected into the combustion-chamber substantially vertically in one direction, and the products of combustion are caused to double back upon themselves in the opposite direction before passing through the opening from the combustion-chamber.

13. In a furnace, a combustion-chamber, a pipe through which a pulverulent fuel may be projected upwardly into the combustion-chamber, the combustion-chamber being open only at or near the bottom thereof near the end of said pipe whereby the products of combustion and unconsumed material will be caused to double back and move downwardly before passing from the combustion-chamber.

14. In a furnace, a combustion-chamber open only at or near the bottom thereof for the passage of products of combustion, said combustion-chamber surrounded by an air-space and having a channel in its wall communicating with said space through which a gas may be supplied to the combustion-chamber, means for controlling the supply of gas, and means for injecting upwardly into the combustion-chamber pulverulent material.

15. In a furnace, a combustion-chamber having an opening near the bottom thereof for the passage of products of combustion, said combustion-chamber also being open at its lower end through which slag or other unconsumed material may fall, a device for catching said material, means for conveying away said material and an upwardly-extending pipe through which material to be burned may be injected into the combustion-chamber.

16. In a furnace, a combustion-chamber, having an opening for the passage of products of combustion and another opening in the bottom thereof for the escape of slag or other unconsumed material, a second chamber adjacent to the combustion-chamber into which the products of combustion pass having an opening in the bottom thereof through which ash or other material carried

by the products of combustion may escape, and means extending from the opening in the bottom of the combustion-chamber to the opening in the second chamber adapted to remove both the slag and ash.

17. In a furnace, a combustion-chamber and a boiler-chamber, separated by a wall having an opening through which products of combustion pass to the boiler-chamber, the bottom of the combustion-chamber provided with an opening for the escape of slag and the bottom of the boiler-chamber provided with an opening for the escape of ash or other material, and an endless carrier extending from the opening under the combustion-chamber to the opening under the boiler-chamber for the purpose of removing both the slag and ash.

18. In a furnace, a vertical combustion-chamber closed except at or near the bottom, means for supplying to the combustion-chamber pulverulent fuel and a supporter of combustion, said means being so arranged with respect to the combustion-chamber that the incoming fuel will support or hold in suspense some of the particles of the burning fuel.

19. In a furnace, a vertical combustion-chamber closed except at or near the bottom and a single means for supplying to the combustion-chamber a mixture of fuel and a supporter of combustion, said means being so arranged with respect to the combustion-chamber as to cause some of the particles of the burning fuel to be supported or held in suspense by the incoming mixture.

20. In a furnace, a combustion-chamber open at or near its lower end for the passage of products of combustion and unconsumed material and means for injecting material to be burned into the combustion-chamber, the said means being so arranged as to keep some of said material in suspense while the material is burning.

21. In a furnace, a combustion-chamber, means for supplying to the combustion-chamber a fuel and a supporter of combustion, said means being so arranged as to cause the burning fuel and products of combustion to double back and to envelop the incoming fuel.

22. In a furnace, a combustion-chamber, closed except at or near the bottom thereof, means for supplying pulverulent fuel into the chamber near where it is open, the parts being so arranged as to cause the products of combustion and unconsumed particles to double back and envelop the incoming fuel before passing from the combustion-chamber.

In witness whereof I have hereunto set my hand, at Johannesburg, South Africa, this 11th day of March, 1905.

ANTHONY M. ROBESON.

In presence of—
THOS. GREY,
W. J. CLARKSON.

In witness whereof I have hereunto set my hand, at the city of New York, in the county of New York and State of New York, this 31st day of January, 1905.

CLAUDE A. BETTINGTON.

In presence of—
LOUIS N. WHEALTON,
T. R. RICHARDS.