July 6, 1926. 1,591,679

C. G. HAWLEY

PROCESS FOR THE COMBUSTION OF ASH CONTAINING FUELS

Filed Jan. 15, 1921 2 Sheets-Sheet 1

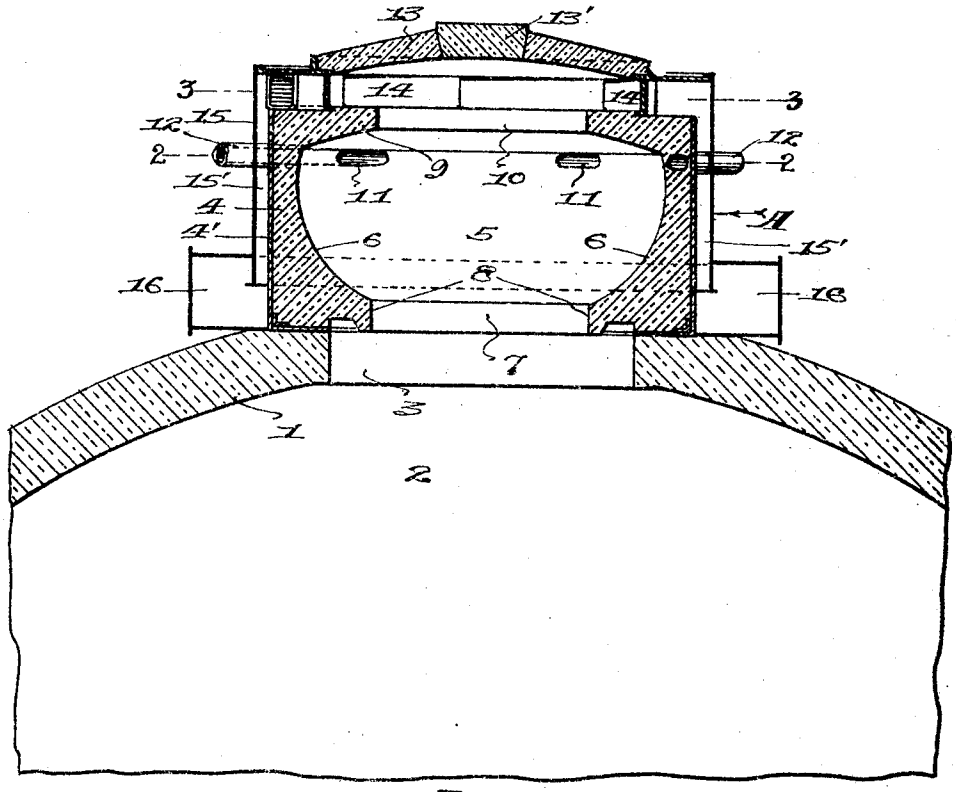


FIG. 1.

FIG. 2.

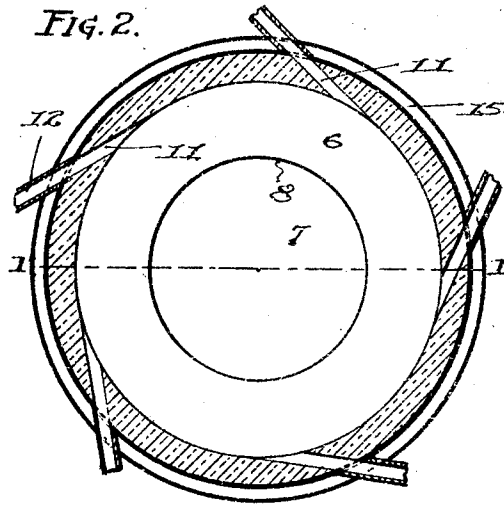
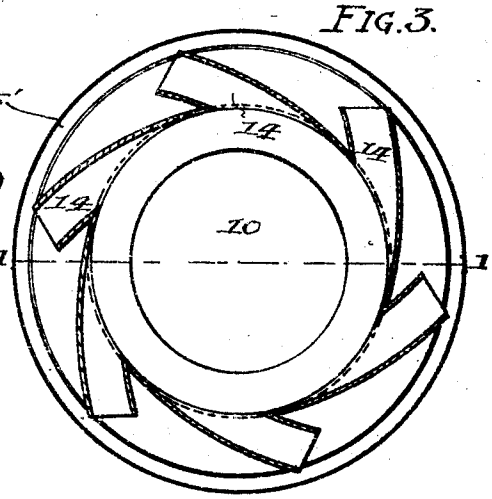


FIG. 3.



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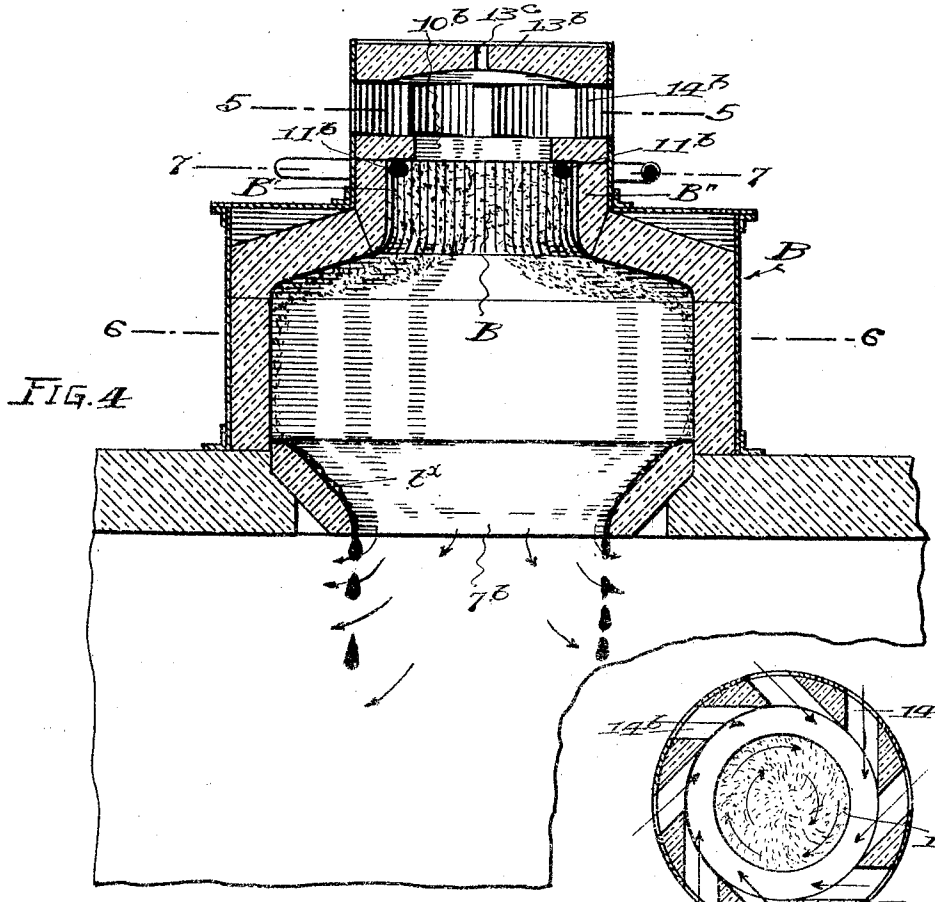


FIG. 4

FIG. 5

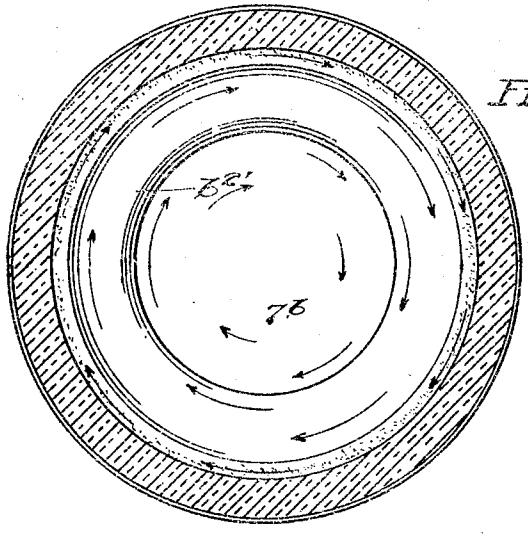


FIG. 6

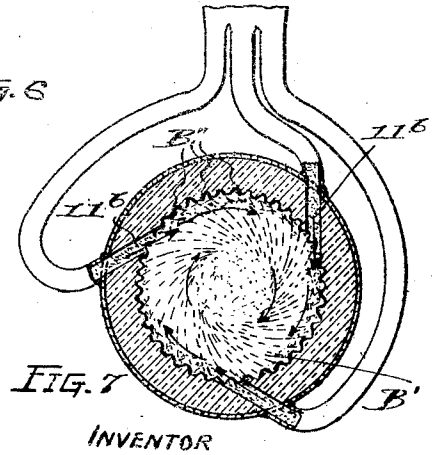


FIG. 7

INVENTOR



Patented July 6, 1926. 1,591,679

UNITED STATES PATENT OFFICE.

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PROCESS FOR THE COMBUSTION OF ASH-CONTAINING FUELS.

Application filed January 15, 1921. Serial No. 437,614.

By this invention the fuel and the combustion supporting air are taken in at the top of an annular combustion chamber and the flaming products of combustion and the molten ash are delivered downwardly through a large opening in the bottom thereof.

The novel process of this application, as best practiced, consists in inducing progressively, a downward flow of combustion supporting air through a chamber having suitable refractory walls and which leads to the space wherein the heat is to be utilized;—second,—progressively injecting fuel into the downwardly moving air as it enters the top of said chamber;—third,—igniting the mixture of fuel and air;—fourth,—imparting rapid rotation to the flaming mixture within said chamber whereby a portion of the fuel is burned in suspension therein while the remainder is centrifugally and gravitationally deposited upon the walls of said chamber there to burn in a comparatively leisurely manner under the action of the high temperature of combustion and the whirling or sweeping currents of air and gases;—fifth,—discharging the flaming products downwardly from said chamber;—and, sixth, simultaneously fusing the fuel ash and discharging the same from said walls by gravity.

Incidentally I conduct the combustion within the annulus or chamber at such high temperatures that the fuel ash is substantially liquefied so that it freely drains from the chamber in the form of slag.

Structurally, my present invention comprises a generally round or cylindrical refractory annulus having a substantially vertical axis and provided with a large central outlet in its bottom and with one or several air intake openings in its top, in combination with an arrangement for feeding fuel to said annulus and for setting the mixture of air, fuel and gases in rapid rotation therein. Though not limited thereto, I prefer to admit the combustion supporting air through a plurality of tangential twyers, which operation aids in setting up the requisite rotary motion within the annulus; and, likewise, by preference, I employ an air blower and a plurality of tangential fuel twyers as the means for introducing pressure air and the fuel into the annulus at a velocity which adds to and positively ensures the vigorous whirling action of the mixture and products within the annulus.

As a rule my furnace will be placed upon the top of the fire space or chamber to be heated and will deliver its flame downwardly thereinto. Though not so shown herein each said fire chamber is provided with a floor or hearth to receive the slag and, occasionally, solid particles of residual fuel from the furnace. The rejected fuel burns upon said floor or hearth. A slag drain hole (not shown) is provided in the floor or hearth; and, if desired, the slag hole may be separately heated as pointed out in my said application, Serial No. 437,615.

It will be understood that my invention is especially intended for the burning of all kinds of ash bearing fuel; but, more particularly, for indiscriminately crushed or screened coal.

The several matters which markedly distinguish my invention are of great simplicity, but nevertheless make it possible to burn the poorest as well as the best grades of ash-containing fuels; make it possible to disregard the condition of the fuel as mined; make it possible to wholly dispense with grates and their attendant limitations;—make it unnecessary to finely pulverize, or to dry, the fuel before burning it; make it possible to burn coarsely screen, ground or crushed fuels, the only limitation being that the prepared fuel shall not be so coarse or so wet as to prevent its reliable and economical conveyance to the furnace;—make it possible to burn efficiently those fuels which contain maximums of water, sulphur, and ash, and to do so without clogging or interrupting the operation of the apparatus wherein the combustion is conducted; make it possible to efficiently burn a maximum of fuel within a minimum of space;—make it possible to efficiently burn either a small or great quantity of fuel within a given space;—make it possible to accurately regulate, intensify, or lower the fire, or shut it off, and instantly start it after a considerable period of shut down; make it possible to continuously maintain a fire of desired intensity, without diminution or shut down from any cause other than natural wear, or the necessities of furnace inspection;—make it possible to burn fuel with that limited quantity of air which theoretically is required for its com-

bustion, thereby obviating the very common heat losses due to excess air;—and, furthermore, ensure that elevation of temperature and that intimacy of contact between fuel particles and heated air which is needed for the rapid and complete combustion of the fuel;—and, also, ensure a constant separation and discharge of the incombustible solids. Further, such matters of distinction admit of the highest possible temperatures and efficiencies from any given fuel and the object heated thereby; all with assured safety; and with a minimum outlay for fuel preparation, fuel handling, air supply, furnace construction, and furnace maintenance.

Even under the most exacting conditions that my invention has to meet, it is rare that the coal need be so far reduced as to pass through openings of $\frac{1}{16}$ inch diameter, and no other sorting or sizing operation is required; and much coarser fuel may be burned. Whatever size is decided upon, the whole product, fine and coarse, is passed through a screen, or the like, containing openings of approximately the size decided upon; and there the manufacturing operation ends. Such rough screening, milling, crushing or reduction of the coal can be carried on without sorting or drying of the fuel. This is a matter of great economical importance.

The invention will be readily understood upon reference to the drawings, which form part of this specification; and wherein:—Fig. 1 is a vertical section, on the line 1—1 of Figs. 2 and 3, depicting a simple form of the novel furnace which is associated with the practice of my new process;—Fig. 2 is a horizontal section on the line 2—2 of Fig. 1;—Fig. 3 is a horizontal section on the line 3—3 of Fig. 1;—Fig. 4 illustrates a modification of the furnace wherein I have shown, in one form, a pre-combustion or firing chamber, for the better carbonization of the fuel before it reaches the lower or main combustion chamber;—Fig. 5 is a horizontal section on the line 5—5 of Fig. 4;—Fig. 6 is a section on the line 6—6 of Fig. 4;—and Fig. 7 is a horizontal section on the line 7—7 of Fig. 4.

The drawings do not show any particular association or use of my furnace, for it is to be at once understood that my invention is applicable practically to any use and every industry requiring a furnace; particularly including all which employ ash-containing fuels and demand safety and simplicity of operation, or the best economies or high temperatures, or easily regulated temperatures, or long sustained constant temperatures; and also such as require either an oxidizing or a non-oxidizing heat, which adjustments involve merely a correct proportioning of the fuel and air at the intakes of my furnace.

The part 1 appearing in Figs 1 and 4, represents the roof or arched top of a fire chamber, 2, wherein the heat of my furnace is utilized. It is to be understood that each fire chamber, 2, is connected with a suitable gas discharge duct, stack or chimney. In each case, as here shown, the roof, 1, contains a large hole, 3, wherein the outlet of my furnace, A, is so disposed as to deliver the furnace flames downward into the space, 2. As before stated, each space has a sloping floor or hearth (not shown) to receive the solid products (chiefly molten slag) from the furnace; and each hearth contains a drain hole (not shown) for the ultimate discharge of the slag into an underlying pit.

The several parts of the furnace, A, of Figs. 1, 2, and 3, may be briefly identified as follows: The part, 4, is a generally round or cylindrical annulus having thick walls made of firebrick or other refractory material adapted to withstand temperatures approximating one thousand degrees Fahrenheit. The annulus may have a metal container, 4′, to keep it in shape. The inner chamber, 5, is the main combustion chamber of my furnace and is defined by the preferably bowl-shaped inner surfaces, 6. At the bottom, the annulus contains the large outlet, 7, through which, preferably, all the products of the furnace are discharged. The overhanging annular part, 9, of the chamber, 5, contains an air intake opening, preferably a single central hole, 10, through which I prefer to admit the greater part of combustion supporting air. The openings, 11, are best arranged at the top of the side walls, 6, and are tangential twyers, wherewith respective fuel supply pipes, 12, are connected. The pipes, 12, lead from any suitable pressure air blower and fuel feeder (not shown) adapted to supply a relatively small volume of air or other oxidizing gas at high velocity, and therewith a regulably measured quantity of the fuel.

The refractory top or cover, 13, of the annulus prevents the loss of radiant heat from the interior of the furnace. This is spaced away from the furnace part, 9, by a plurality of large tangential intake twyers, 14; which may comprise a metal casting and serve as the support for the top or cover, 13.

The part 15 is a metal shield or casing that surrounds the annulus and is spaced therefrom to form an annular air intake duct, 15′, leading from a point near the bottom of the furnace to the air intake twyers, 14. This is essentially an air preheating device, whereby the heat radiated by the annulus is saved and combustion within the furnace is improved.

In most cases the downward movement of air within the annulus is imparted by the draft of the aforementioned chimney belonging to the fire-chamber, 2. But in other

cases I resort to the use of a pressure air trunk, 16, from which to supply the air admission or pre-heating duct, 15'.

Obviously both methods (chimney induced draft and blower induced draft) ensure the rapid inflow of air at the top of the furnace. The intake opening or openings are of a size to admit only so much air as is required for the desired combustion of the quantity of fuel which the furnace is to burn. As should be apparent, air admitted at the openings, 14 and 10, is augmented by the supply of air from the twyers, 11. The total volume supplied usually is that quantity which is theoretically requisite to the combustion of the given quantity of fuel fired or supplied (through the twyers, 11, or otherwise) to the combustion chamber, 5. A suitable damper, or dampers, (not shown) control the rate of flow of the air at intake of the furnace; and thereby, the accurate proportioning of air and fuel is made possible.

The tangential position of the twyers, 14, results in setting the inflowing body of air into rapid rotation within the chamber, 5, and such initial rotation is effectively augmented by the action of the high velocity air streams entering through the smaller fuel twyers, 11. This rotation is a factor of great importance for its ensures an extremely intimate admixture of fuel particles and gases with the incoming air, and also results in precipitating and temporarily holding the heavier particles of fuel and fuel ash upon the inner surfaces, 6, of the combustion chamber.

The cover, 13, contains a lid 13', which may be opened to admit a pilot torch or starting flame. Most conveniently, at starting times such a pilot flame is temporarily established in the top of the combustion chamber, then the flow of air is started through the twyers, 14, and downward through the opening, 10, and chamber, 5. With the arrangement here shown, air thus admitted is set into rapid rotation. Following the establishment of the whirling downward flow of the air, the fuel is blown into the annulus through the twyers, 11, and being restrained by the walls of the annulus, travels helically thereon in a gradual downward direction. Obviously the blast of air from the twyers, 11, coupled with the twisting flow downward through the opening, 10, not only institutes and maintains the rotative action of the fuel in the chamber, but also holds the air and other gases in sweeping contact with the fuel on the chamber walls.

By preference, I make the bottom portion of the chamber of such inclination as to insure the automatic discharge of the fuel which fails of combustion within the chamber and reaches the outlet, 7. This is of special advantage at times of starting the fire. At such times the finer fuel particles are ignited and effectively burned, while many of the heavy particles escape from the combustion chamber through the outlet. However, this condition persists only for a short time; for, as about to be explained, the increase of temperature within the combustion chamber is so rapid as to quickly reach a stage which ensures the breaking up and consumption of practically all of the fuel particles while still within the chamber.

As described, the fuel which enters the conbustion chamber, 5, is usually coarsely crushed coal made up of small and large particles. The finer particles of fuel take fire from the pilot flame almost instantly upon leaving the twyers, 11, such finer particles being thrown into a state of suspension within the chamber, 5, both by reason of deflection upon the rough surfaces of the chamber, and by reason of their displacement from the walls by the heavier particles. In consequence, of this initial firing of the finer particles, a great mass of fire is quickly set up within the combustion chamber. Thereupon the pilot flame may be withdrawn, and the lid, 13', closed. From such time onward, more and more of the fuel burns while passing through the chamber, 5, until finally under the described intimacy of admixture such high temperatures are attained as to ensure a rate of combustion so rapid as to consume practically all of the fuel before it can reach or be discharged from the outlet or mouth, 7, of the furnace. Any fuel particles which fall upon the hearth or underlying floor are allowed to burn thereon.

An important feature of my process is that the greater part of the fuel ash is projected from the whirling body within the chamber, 5, and is finally left or deposited upon the wall surfaces, 6, thereof. Under the high temperatures attained, the ash is there fused; with the result that it drains from the chamber outlet, 7, in the form of molten slag.

The outlet, 7, may be characterized by a slag dripping edge, 8. This is of chief utility when the furnace is to be operated at comparatively low temperatures that do not reduce the fuel ash beyond a slow-flowing, plastic state.

Obviously, my process includes the important steps of fuel and air regulation to suit the combustion to the work to be performed.

Turning now to Figs. 4 to 7 of the drawings: It will be seen that the furnace, B, shown herein, closely resembles the one above described; but has an added story, chamber or space, B'. I admit the fuel to the chamber, B', through tangential twyers, 11^b, and preferably the vertical walls, B'',

of the chamber, B′, are corrugated, as well shown in Figs. 4 and 7. The chamber, B′, receives the fuel and air and serves as a mixing and firing chamber wherein the combustion is initiated. It also serves as a confining space wherein the downwardly moving column of air is momentarily closely confined and set into extremely rapid rotation. The devolatilization or carbonization of the fuel is accomplished in this firing chamber, leaving only the lightened residual fuel particles to be thrown upon the walls of the underlying combustion chamber. By means of this mixing and firing chamber the capacity of the furnace is markedly increased. Also the centrifugal force developed is of longer persistence and is increased, with the result that the larger combustion chamber (lower chamber) may be of lesser size than is the case of the construction shown in Fig. 1.

The furnace of Fig. 4 admits the main body of combustion supporting air through a top central opening, 10^b, and tangential twyers, 14^b. My invention is not limited thereto nor to any particular shape of the combustion chamber. By preference the bottom floor, b^x, of the chamber, B, is made of a conical or inclined form terminating at the outlet, 7^b, to prevent the accumulation of green fuel or coke at times of starting the fire.

The marked advantage of such corrugations resides in the fact that the fuel entering at the tangential twyers, 11^b, is deflected by such projections and is thus directed toward the center of the chamber, B′. In other words, a centripetal action is set up and much or all of the continuously admitted fuel is immediately thrown into suspension within the intensely hot air entering the chamber, B. The centripetal and firing operations are immediately followed by the centrifugal projection of the fuel into the underlying larger portion or combustion chamber, where ample wall space is provided for the reception and complete combustion of the large particles of residual fuel which reach the same.

The furnace top or cover, 13^b, contains a peek hole, 13^c, through which the starting or pilot flame may be set up, with the effect as before described.

I wish it to be definitely understood that my invention is not limited to the tangential entrance of the fuel; and further, that in some cases I may not even employ a supply of pressure air through tangential twyers, but may depend directly upon the whirling motion imparted to the contents of the furnace by the tangential entrance of the air at the top of the furnace. A pressure difference that injects the air at a velocity of three to four thousand feet per minute, in many cases will be found sufficient for the purposes of this process, including the indrawing of the fuel. In such cases the twyers, 11, will be omitted.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. The herein described semi-suspension process of combustion, that consists in continuously inducing a downward flow of combustion-supporting air through a chamber having suitable refractory walls, and leading downwardly to a space wherein the heat is to be utilized, continuously injecting fuel into the downwardly moving air and imparting rapid rotation to the resulting mixture, igniting said mixture within said chamber whereby a portion of the fuel is burned in suspension therein while the remainder is deposited upon the walls of said chamber and there burned, and discharging the fuel ash into said space by the action of the downward moving air and gravity.

2. The process of burning coal in semi-suspension that consists in continuously inducing, as by chimney draft, a downward flow of combustion-supporting air through a refractory annulus which leads to the space wherein the heat is to be utilized, injecting the fuel into the moving air as it enters the top of said annulus, there continuously igniting the mixture of fuel and air, and simultaneously projecting a relatively small volume of pressure air tangentially into said annulus below the top thereof, and thereby imparting rapid rotation to the flaming mixture within said annulus and burning a portion of the fuel in suspension therein, while centrifugally projecting the remainder thereof upon the walls of the annulus and there burning the same in a comparatively leisurely manner under the action of the whirling currents of air and gases, and finally permitting the downward discharge of both the flaming products and the fused ash continuously into said space.

3. The herein described semi-suspension combustion process, which consists in setting up a flow of air downward in the form of a column within a refractory annulus, injecting fuel into the column, firing the mixture, setting the column of mixture in rotation, thereby causing a portion of the fuel to be burned in suspension and the remainder thereof to be projected against and burned upon the inner walls of said annulus, and discharging the resultant flames and fuel ash downward from said annulus into a suitable fire-and-ash-receiving chamber where the heat is utilized.

In testimony whereof, I have hereunto set my hand this 11th day of January, 1921.

CHARLES GILBERT HAWLEY.