No. 776,171. PATENTED NOV. 29, 1904.

H. C. CALDWELL.

METHOD OF PRODUCING COMPLETE COMBUSTION.

APPLICATION FILED OCT. 26, 1903.

NO MODEL.

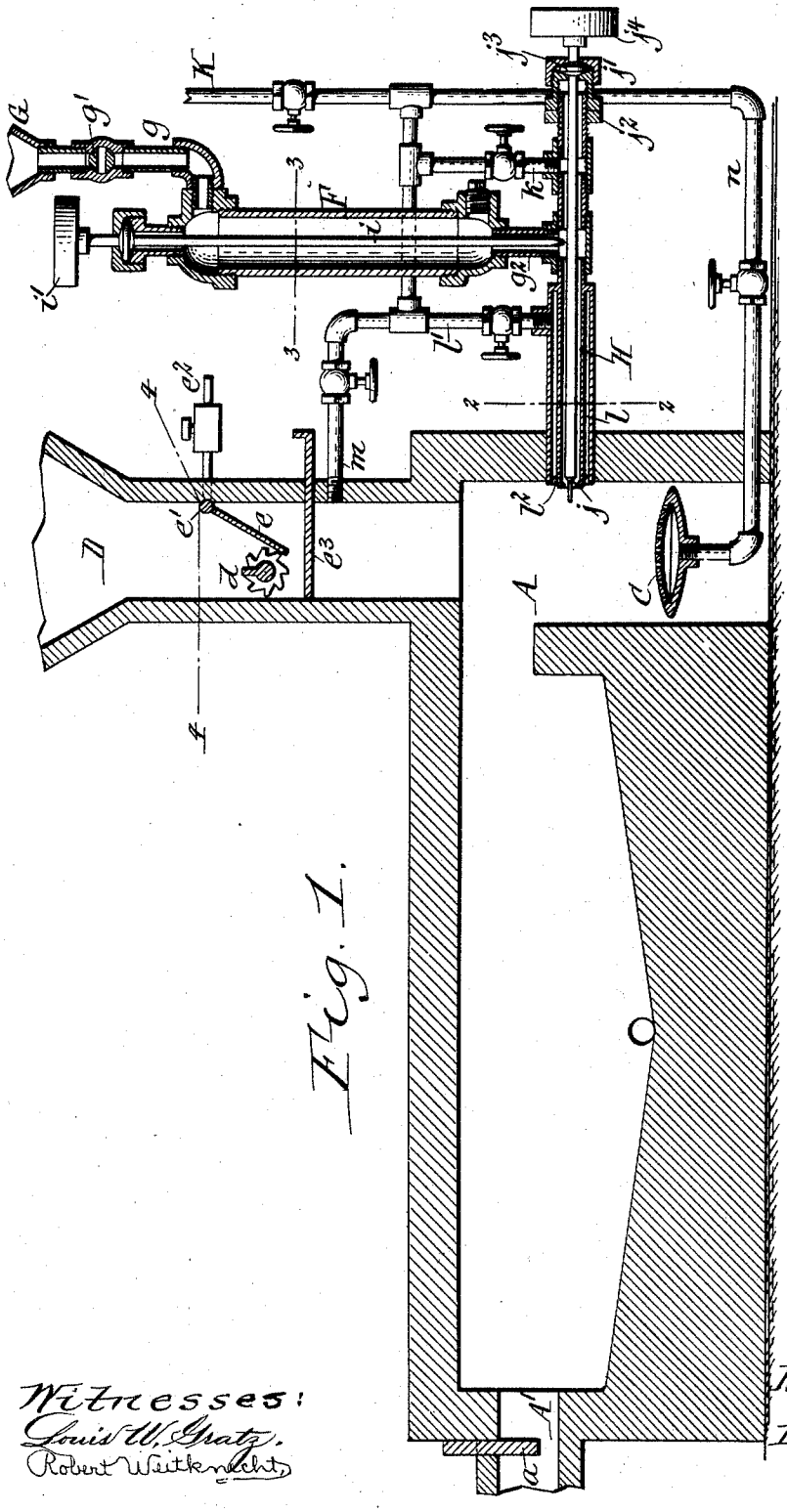


Fig. 1.

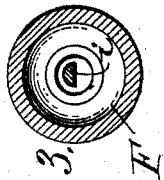


Fig. 3.

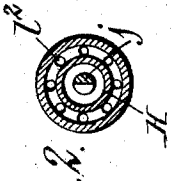


Fig. 2.

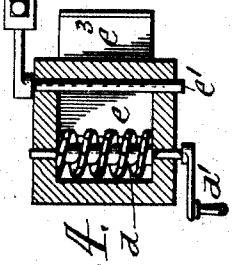


Fig. 4.

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No. 776,171. Patented November 29, 1904.

UNITED STATES PATENT OFFICE.

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METHOD OF PRODUCING COMPLETE COMBUSTION.

SPECIFICATION forming part of Letters Patent No. 776,171, dated November 29, 1904.

Application filed October 26, 1903. Serial No. 178,461. (No model.)

To all whom it may concern:

Be it known that I, HENRY C. CALDWELL, a citizen of the United States, residing at Buffalo, in the county of Erie and State of New York, have invented new and useful Improvements in Methods of Producing Complete Combustion, of which the following is a specification.

The objects of my invention are to produce in an economical manner complete and controlled combustion of solid and semisolid fuel or combustible material and to attain high temperatures suitable for metallurgical and other processes requiring a high degree of heat.

The invention consists to that end of the improved method hereinafter described, and pointed out in the claims.

In the accompanying drawings, Figure 1 is a sectional elevation of a furnace in which my improved method may be carried out. Fig. 2 is an enlarged cross-section of the feed-nozzle in line 2 2, Fig. 1. Fig. 3 is an enlarged horizontal section of the fuel-chamber in line 3 3, Fig. 1. Fig. 4 is a similar section of the main fuel-hopper in line 4 4, Fig. 1.

Similar letters of reference indicate corresponding parts throughout the several views.

My improved method of producing combustion consists, essentially, in preparing a mixture of finely-divided fuel and water and introducing such previously-prepared mixture into a combustion-chamber in the presence of an incandescent bed of solid fuel or other suitable source of heat.

The method may be practiced in the furnace which is shown in the drawings and which is constructed as follows:

A indicates the combustion-chamber, provided at its rear end with a comparatively small escape-passage A′ for the products of combustion. This passage may be controlled by a damper *a*.

C is a grate or twyer arranged in the front portion of the combustion-chamber and adapted to support a bed of solid incandescent fuel. Any other suitable heater may be substituted for this twyer, such as a gas-burner or an electric heater.

D is a hopper or feeder for solid fuel arranged at the top of the furnace directly over the twyer and adapted to supply fuel to the latter. The discharge-throat of this hopper preferably contains a horizontal agitating or feed screw *d* for loosening the fuel, the shaft of this screw extending through the wall of the hopper and having a hand-crank *d′*, as shown in Fig. 4. The discharge-throat may also may be provided with an internal gate or valve *e*, which bears yieldingly against one side of the agitating-screw *d* and serves to retard the delivery of the fuel into the combustion-chamber, thereby causing but a few pieces to be fed to the twyer at a time. In the construction shown in the drawings this retarding-gate is secured to a horizontal rocking shaft *e′*, journaled in the walls of the hopper and having a weighted arm e^2, which presses the gate against the screw. A slide or cut-off e^3 may be arranged in the hopper below the agitating-screw.

F is a chamber or receptacle for the mixture of finely-divided fuel and water. This chamber receives the mixture from a feed-hopper G, with which it is connected by a pipe *g*, having a suitable hand-valve *g′* for controlling the flow of the mass into the chamber. The delivery-pipe g^2 of this chamber is connected with a horizontal feed tube or nozzle H, which opens into the combustion-chamber A above the twyer C, so that the mixture of finely-divided fuel and water issuing from the nozzle is ignited and consumed by the bed of incandescent fuel on the twyer. The chamber F contains a suitable agitator or stirrer *i*, consisting, preferably, of a rotary half-round rod arranged centrally therein and in its delivery-pipe g^2. This rod extends through a suitable stuffing-box at the top of the chamber and is provided at its upper end with a pulley *i* driven by a suitable motor. (Not shown.)

The delivery-orifice at the front end of the feed-nozzle H is controlled by a valve *j*, which

may consist of a rod arranged lengthwise in the nozzle and having a conical front end adapted to seat against the beveled edge of said orifice. The valve-rod extends through a stuffing-box j'' at the rear end of the nozzle H, which box is longitudinally adjustable on the nozzle by means of a screw-threaded connection or otherwise, so that the valve may be opened, more or less, by turning the stuffing-box on the nozzle. After effecting the adjustment the box is clamped in position by a jam-nut j^2. The valve-rod is compelled to move with the stuffing-box by a collar j^3, mounted on the rod and arranged between the members of the box. The valve-rod is also preferably employed as an agitator for loosening the material in the nozzle, and for this purpose the rod may be made half-round, like the stirrer i, and provided at its rear end with a pulley j^4, as shown, for driving it.

K is a main pressure-supply pipe connected with a suitable source of pressure, as a compressed-air tank, and k is a branch pipe connecting said supply-pipe with the portion of the feed-nozzle H on the rear side of the chamber F, whereby the air-pressure expels the mixture of fuel and water from the chamber F and forces it through the nozzle H into the combustion-chamber A. The front portion of this nozzle is preferably surrounded by a cooling pipe or jacket l, to which cold air is supplied by a branch pipe l', connected with the air-supply pipe K, the jacket being provided in its front end with apertures l^2, through which the air issues into the combustion-chamber. This cooling-jacket prevents overheating of the feed-nozzle H and premature coking of the fuel contained therein, thus avoiding clogging of the nozzle.

m is a branch pipe connected with the main pipe K and leading to the portion of the solid-fuel hopper D below the feed-screw d. The pipe m delivers a blast into the lower portion of the hopper and downwardly into the upper portion of the combustion-chamber. This blast cools the hopper and prevents the flame in the combustion-chamber from rising into the hopper D.

n is a blast-pipe leading from the main pressure-pipe K to the twyer.

The main pressure-pipe K and the several branch pipes k, l, m, and n are provided with suitable hand-valves, as shown, for regulating or entirely shutting off the air-pressure from the furnace, as desired.

In practicing my improved method in the above-described furnace a fire of solid fuel, preferably anthracite or dense coke, is started on the twyer C, and the air-blast is admitted to the latter. When this bed of fuel reaches an incandescent state, the valves of the pipes k, l', and m are opened for admitting compressed air to the feed-nozzle H, the chamber F, the cooling-jacket l, and the main feed-hopper D. At the same time the agitators i and j are caused to be operated slowly or with just sufficient speed to insure a regular and uniform delivery of the semiliquid mass of finely-divided fuel and water into the combustion-chamber, the air-pressure in the chamber F being properly regulated to force the mixture slowly or gradually into the combustion-chamber. The air-blast is also so regulated that the pressure in the main feed-hopper D slightly exceeds the pressure in the combustion-chamber A, and so that the pressure of the blast delivered through the feed-nozzle H exceeds the pressure in the combustion-chamber. The mixture of finely-divided fuel and water upon entering the combustion-chamber is immediately raised to a red heat and the water combined therewith is converted into superheated steam. The same conditions thus exist as in the water-gas producer—that is, superheated steam in contact with highly-heated carbon—and the same result—the production of water-gas—therefore follows. The gas, however, at the moment of its production is mixed with highly-heated air and practically perfect and complete combustion is the result. The air employed for forcing the semiliquid fuel into the combustion-chamber and for cooling the feed-tube H is insufficient for the combustion of the fuel, and therefore at the point where the semiliquid fuel is introduced the conditions of a water-gas producer prevail. The air required for the combustion of the resulting gases is furnished by an independent supply in connection with the source of heat C. By the above reaction a considerable amount of heat is absorbed; but this loss is compensated for by the incandescent bed of fuel on the twyer C, which acts as an independent source of heat and a regulator of heat energy for supplementing and regulating the heat resulting from the combustion of the semiliquid mass of fuel and water issuing from the feed-tube H. Any carbon not volatilized by the action of the water, together with the ash, falls upon said incandescent bed, which is maintained at a proper depth or thickness by a regulated supply of fuel from the hopper D.

By a proper regulation of the fuel-feed and the air-pressure perfect control of the combustion is possible, and theoretically any temperature may be attained by a proper relationship of air-pressure to speed of fuel-feeding through the nozzle H; but in practice the attainable degree of temperature will of course be limited by the surroundings as to absorptive power of heat. By mixing the finely-divided fuel with water before delivering the same into the combustion-chamber the feed of the mass is greatly facilitated and brought under perfect control, the water acting as a vehicle or lubricant which enables the fuel to be fed with absolute certainty in the desired quantity.

The mixing of water with the fine fuel not only facilitates the regular feeding of the fuel, but also has an important influence on the combustion of the carbon. Every volume of water by its transformation into superheated steam is expanded into about eighteen hundred to two thousand volumes. Every volume of steam in its decomposition produces one volume of hydrogen and half a volume of oxygen, which latter in combining with carbon produces one volume of carbon monoxid, or for every volume of steam one volume of hydrogen and one volume of carbon monoxid are obtained—that is, two volumes of combustible gases. Hence, for every volume of water introduced about six thousand volumes of gas are obtained at a temperature, say, of about 1,000° Fahrenheit. These require three thousand volumes of oxygen for combustion, producing about six thousand volumes of products. As three thousand volumes of oxygen if introduced without without water would have produced three thousand volumes of carbonic acid, it is evident that the introduction of the water has about doubled the volume of the gases in the combustion-chamber disregarding the presence of nitrogen, and if this chamber is closed the pressure therein will also be about doubled. This increase of pressure is produced directly in the combustion-chamber at the expense of a small percentage of the heat energy of the fuel and not by extraneous mechanical energy. It is necessary to supply by the blast only the oxygen required to consume the carbon and not an excess mixed with four times its volume of nitrogen, thus effecting a considerable saving in mechanical energy usually consumed in producing the blast. It is understood by those skilled in the art that the temperature in the combustion-chamber rises as the pressure therein is increased, or, in other words, that combustion under high pressure must also be combustion at high temperature. By forcing the semiliquid fuel-mixture into a nearly-closed chamber maintained at a high temperature and pressure the water at once vaporizes and, as above shown, greatly increases in volume by so doing; but as it cannot freely escape it increases the pressure in the chamber, and consequently much less air need be forced into the chamber to maintain the pressure. The vaporization of the water of course consumes heat energy, but produces a much higher pressure than could be obtained from the same amount of energy when applied through an engine and blower.

As the water at the point of its delivery into the combustion-chamber is vaporized in the presence of incandescent carbon and with deficiency of oxygen it becomes a volatilizer of the carbon in the form of carbon monoxid, the energy consumed in the decomposition of the water being subsequently restored by the combustion of the hydrogen.

This improved method affords another very important advantage, for inasmuch as the steam furnishes the pressure for obtaining high temperatures it is only necessary to feed an excess of semiliquid fuel in proportion to the air-supply in order to produce a gas mixture rich in hydrogen and carbon monoxid at a very high temperature, and therefore capable of exerting a powerful reducing action upon metallic oxids, &c. This is of great value in metallurgy and renders possible metallurgical operations heretofore unattainable except by electrical furnaces of low efficiency. On the other hand, by a relatively high air volume a powerful oxidizing action can be readily produced, and these conditions are perfectly under the control of the operator from the fact that the previously-prepared mixture of fuel and water is introduced in a predetermined ratio.

Any suitable material containing carbon may be employed when finely divided and used in conjunction with water. However, the richer the fuel is in combustible material the less of solid dense carbon will be required for the heating-bed on the twyer. Peat, muck, sawdust, and other carbonaceous material heretofore of practically little or no fuel value thus become available for the production of the highest temperatures attainable by combustion with no other treatment or preparation than grinding the same to the requisite degree of fineness and mixing it with water. The quantity of water used in the mixture depends upon the amount of carbon in the particular combustible material employed. If the material is rich in carbon, more water is required than if the material contains a small percentage of carbon.

I am aware that prior to my invention it has been proposed to inject by an air-blast pulverized fuel or carbonaceous material into a combustion-chamber over a burner or an incandescent bed of fuel, the latter being used mainly for starting the fire and insuring a continuous burning of the fine fuel by reigniting it in case of temporary interruption. I am also aware that it has been proposed to introduce separately into a combustion-chamber finely-divided solid fuel and a spray of water or a jet of steam for the purpose of reducing the intensity of the combustion while increasing the efficient volume thereof; but this method renders it practically impossible to control the proportions of the fuel and water or steam in such manner as to secure the results obtained by the herein-described method. My improved method differs from the prior method last referred to in that all portions of the finely-divided fuel are intimately mixed with water before being introduced into the combustion-chamber and in

that this previously-prepared paste-like mixture upon entering the combustion-chamber is subjected to the effect of an incandescent bed of fuel or other suitable independent source of heat.

I claim as my invention—

1. The herein-described method of producing combustion, which consists in introducing into a combustion-chamber finely-divided combustible material and water in an intimately-mixed state, and subjecting the same therein to the action of a source of heat independent of that produced by the combustion of the mixture of combustible material and water, substantially as set forth.

2. The herein-described method of producing combustion, which consists in preparing a paste-like mixture of finely-divided combustible material and water in predetermined proportions, and then introducing such previously-prepared mixture into a combustion-chamber in the presence of a source of heat independent of that produced by the combustion of said mixture, substantially as set forth.

3. The herein-described method of producing combustion, which consists in mixing finely-divided combustible material with a predetermined quantity of water, delivering said previously-prepared paste-like mixture into a combustion-chamber and at the same time maintaining said chamber at a high temperature by an independent source of heat, substantially as set forth.

Witness my hand this 23d day of October, 1903.

HENRY C. CALDWELL.

Witnesses:

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EMMA M. GRAHAM.