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C. ELLIS.

PROCESS OF CALCINING LIME AND CEMENT FORMING MATERIAL.

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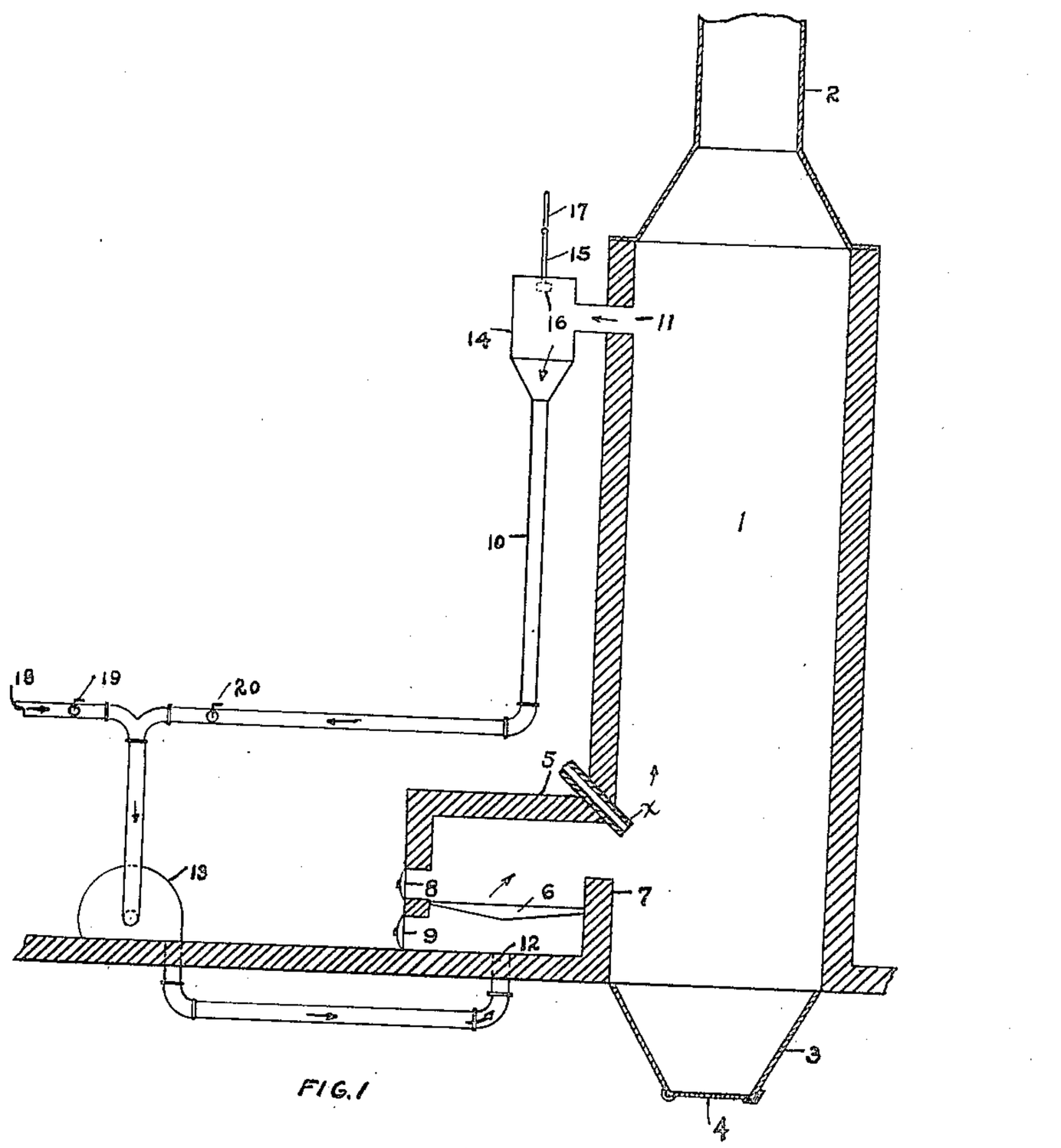

FIG. 1

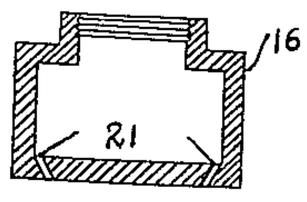

FIG. 2

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PROCESS OF CALCINING LIME AND CEMENT FORMING MATERIAL.

No. 843,878. Specification of Letters Patent. Patented Feb. 12, 1907.

Application filed December 6, 1905. Serial No. 290,580.

To all whom it may concern:

Be it known that I, CARLETON ELLIS, a citizen of the United States, and a resident of White Plains, in the county of Westchester and State of New York, have invented certain new and useful Process of Calcining Lime and Cement Forming Material, of which the following is a specification.

This invention relates to process of burning lime in upright vertical or shaft kilns by means of coal fuel, the combustion of which is conducted in an artificially-accelerated draft containing less oxygen than that normal to air and containing in addition a catalyzing body which facilitates the decarbonation of limestone.

The object of this invention is to control the temperature and volume of flame or combustion and so modify the character of the flame that it is better adapted to the calcination of limestone than the flame customarily employed.

Heretofore the burning of lime with coal as the fuel has been most successfully conducted with a draft-current of air and a neutral gaseous diluent of suitable volume and velocity, the diluent consisting, preferably, of products of the calcination of lime and of substantially complete combustion of the fuel. This diluent when present in suitable proportion serves to cool the fire and to retard the chemical activity of the flaming current of gases and air passing from the fuel-bed, thereby increasing the volume of flame, so that the combustion is completed to a great extent in the body of the lime-rock.

The present process involves the use of stack-gas or products of combustion or other diluent gas for the purpose of securing the low temperature desired and in addition involves, essentially, the use of a catalyzing agent, preferably water-vapor or steam, to effect the easy liberation of carbon dioxid from the limestone.

Experiments have shown that if carbonate of lime be heated up to a temperature at which it dissociates and a current of air is passed thereover that the carbon dioxid is rapidly removed, provided the temperature is maintained. As soon, however, as the temperature is allowed to fall the carbon dioxid forthwith decreases in amount and finally ceases altogether. At this point if water-vapor or steam be introduced with the air-current carbon dioxid will again be given off from the limestone, although at too low a temperature for dissociation with the dried or moisture-free air. This important fact is made the basis of the present invention.

My invention consists in conducting combustion with an artificially-accelerated draft-current containing less oxygen than that contained in ordinary air, said draft-current being preferably produced by mixing with ordinary or fresh air containing its normal content of approximately twenty-one per cent. of oxygen a definite or predetermined quantity of diluent gas, such as the products of substantially complete combustion departing from the upper part of a lime-kiln or the stack-gases of combustion produced in any other type of furnaces, in mixing therewith, either below or above the fire, a quantity of a catalytic agent, (water-vapor being about the cheapest and most efficient,) and in subjecting the lime-rock to the action of the flame carrying said diluent gas and catalytic agent until calcination is substantially or wholly complete. This catalytic agent facilitating the calcination of the lime acts also to a considerable extent as a catalytic agent, tending to accelerate and intensify the chemical union of the carbon monoxid of the flaming current of gases and air passing from the fuel-bed. For this reason it has a tendency to shorten the flame, thereby tending to cause higher fuel-bed and fire-box temperatures and to decrease the percentage of fuel-gases burned in the calcining-chamber in contact with the lime-rock. By suitably regulating the proportions of the draft-current constituents in accordance with my present invention the favorable catalytic action of the water-vapor in liberating carbon dioxid (CO_2) from the lime-rock may be increased to a considerable extent without too greatly increasing unfavorable effects of its catalytic action in quickening combustion.

By reference to the accompanying drawings it will be seen in what manner my invention may be performed.

In said drawings, Figure 1 shows in a conventional way a sectional view of a lime-kiln of the continuous-draw type. Fig. 2 is a section of an atomizer which is preferably employed in the introduction into the fire-box of the desired amount of water-vapor.

In the drawings, 1 is the shaft of a lime-kiln, having the stack 2 and the hopper or cooler 3, with winged bottom 4 for the removal of the calcined stone.

5 is the fire-box, having the grates 6, the bridge-wall 7, the fire-door 8, and the ash-pit door 9.

10 is a conduit or passage for the return from the upper part of the kiln at 11 to the ash-pit through the opening 12 of a quantity of products of combustion. Interposed in said conduit is a mechanical draft appliance, which is herein depicted diagrammatically as a fan-blower, but which may take any other desirable form according to circumstances. Also introduced in the conduit 10 is the vapor-chamber 14, with which is connected the water-supply pipe 15, terminating in the spraying device 16. (Shown in detail in Fig. 2.) The water-supply pipe 15 is equipped with a valve 17 to regulate the amount of water. Referring to Fig. 2, the atomizer 16 will be seen in section with the diagonal openings 21, serving to direct streams of water against one another, whereby a spray of a very fine character is produced.

18 is an air-inlet connected with the conduit 10 and is provided with a suitable damper 19. The conduit 10 is also provided with a damper 20.

In carrying out my process with the apparatus as above described I draw from the opening 11 through the chamber 14 and pipe 10 a continuous stream of products of combustion, mix therewith through the opening 18 a quantity of air, whereby the proportion of carbon dioxid in the mixture is maintained at from about four per cent., to about eight per cent., and force this mixture by the fan-blower 13 into the ash-pit of the fire-box 5. Simultaneously with the withdrawal of the stack-gas through the opening 11 there is admitted through the atomizer 16 a quantity of water-vapor, (also supplied continuously,) which water-spray is immediately converted into a vapor and is impelled with the other gases into the ash-pit. This mixture travels through the fuel-bed on the grate-bars 6, and some slight decomposition there occurs to certain of the components of the draft-current, due to their reaction on the carbon of the fuel. Carbon dioxid, for instance, is in part split up into carbon monoxid, while water-vapor is to a certain slight extent converted into hydrogen and carbon monoxid. Both of these reactions are endothermic and serve to cool the fire, so that there is less trouble from clinkering than is the case with a fire fed by a supply of fresh air. Ordinarily the fire-bed is thin, so that sufficient oxygen traverses it unchanged and permits of the completion of combustion above the fire-bed. The retarding action of the endothermic constituents of the draft-current—the steam and the carbon dioxid—upon combustion is sufficient to permit the draft-current to be passed through the thin bed of fuel faster than the fuel can react thereon. Thereby can be obtained a body of gas containing unchanged air, unchanged products of combustion, and unchanged steam, all intimately commingled with carbon monoxid and hydrogen resulting from the chemical action of the draft-current upon the fuel; but it is evident that should the fire-bed be of such depth that insufficient oxygen reaches the upper part of the bed to provide for a fairly complete combustion above said bed that air may be introduced from other sources to supply the deficiency. Ordinarily, however, as above stated, the thin fuel-bed which is customarily carried permits of the passage through the fire of sufficient oxygen to complete combustion beyond the upper surface of the fuel-bed. The shaft-kiln as ordinarily constructed for burning lime permits of considerable air passing into the cooler in the lower part of the kiln, which air is usually sufficient for making up any deficiency in the air supplied to the fire-box. A long flame, relatively cool, is thereby produced in the shaft of the kiln 1 and burns the lime uniformly, rapidly, and efficiently. The water-vapor supplied through the agency of the atomizer 16 reacts in some subtle way with the limestone and greatly accelerates its decomposition. As to the exact nature of this catalytic action the investigations made up to the present time are insufficient to determine precisely. I content myself, therefore, with simply noting the fact without endeavoring to explain the *modus operandi* of this obscure phenomenon.

The proportions of diluent gas, water-vapor, and air are in part determined by the composition of the stack-gases. There is some variation in the gas from time to time, owing to the disturbances produced through the charging and withdrawing the lime-rock and lime, respectively. However, the gases will on an average contain twenty-five to thirty per cent. of carbon dioxid and perhaps five per cent. of oxygon, the balance being nitrogen. As from four to eight per cent. of carbon dioxid is ordinarily desired in the draft-current admitted to the ash-pit, a dilution with five or six parts of air is necessary. The quantity of water-vapor introduced should be such that at least one-half per cent., and preferably two to four per cent., of vapor is present in the draft-current. It should be borne in mind that the gases leaving the kiln through the opening 11 may have a temperature of from 600° Fahrenheit to 1,000° Fahrenheit, depending on the height of the kiln, &c., and consequently have a great capacity for moisture. The addition of the moisture in the form of water-spray—that is to say, practically as a liquid—results in some cooling of these gases, inasmuch as the water has to be converted into steam and raised to the mean temperature of the mixture, whereby heat is absorbed. Subse-

quently the stack-gas and water-vapor mixture is further cooled by the addition of air and the temperature brought down to a relatively low degree. A unit-weight of the final mixture therefore has less capacity for holding water-vapor than has a unit-weight of the hot gases withdrawn at 11. Inasmuch as the volume of the gases entering the ash-pit is greater than the volume of the gases withdrawn at 11, the reduction in temperature, and consequent decreased capacity for holding water, may be compensated by increased volume. In any event it is desirable to so proportion the amount of water-vapor introduced with reference to the temperature of the stack-gases and the amount of fresh air admitted as to prevent precipitation of water during transit, as such precipitated water may have too great a cooling action on the fire, owing to the high latent heat of volatilization of liquid water. It is of course possible to admit hot air through the inlet 18, thereby increasing the amount of water which may be introduced as a vapor into the fire. It is also possible to admit the water-vapor above the fire—as, for instance, over the bridge 7, through pipe x, either in the form of spray, or as ordinary steam, or as superheated steam. Flooding the ash-pit with water is an uncertain and undesirable means of introducing the vapor.

My invention effects important economies in the burning of lime, owing to the catalytic action of water-vapor, as aforesaid, in conjunction with the beneficial flame control attendant on the use of diluent gas. The amount of water-vapor admitted is not sufficient to cause the loss at the stack as sensible heat, &c., of any appreciable amount of fuel. It is evident, of course, that a large amount of moisture or steam would cause a loss in this way, and therefore only such quantity of water-vapor should be admitted as is sufficient to secure the desired catalytic action.

What I claim is—

1. The herein-described process of calcining limestone, &c., which consists in passing through a shallow bed of ignited fuel an accelerated draft-current of commingled air, water-vapor and diluent gas at a rate greater than the fuel can react therewith and burning the resultant gaseous mixture in contact with limestone.

2. The process of calcining limestone, &c., which consists in passing through a shallow bed of ignited fuel an accelerated draft-current of commingled air, water-vapor and limekiln-gases at a rate greater than the fuel can react therewith, and burning the resultant gaseous mixture in contact with limestone.

3. The process of calcining limestone, &c., which consists in passing through a shallow bed of ignited fuel an accelerated draft-current of commingled air, water-vapor and limekiln-gases, the water-vapor being present in not to exceed four per cent. and burning the resultant mixture in contact with limestone.

4. The process of calcining limestone, &c., which consists in mixing a predetermined amount of water with hot products of combustion, whereby said water is vaporized, adding a predetermined amount of air, passing the resultant mixture through a shallow bed of ignited fuel at a rate greater than said fuel can react therewith and burning the resultant mixture in contact with limestone.

5. The process of calcining limestone, &c., which consists in mixing a predetermined amount of water with hot limekiln-gases, whereby said water is vaporized, adding a predetermined amount of air, passing the resultant mixture through a shallow bed of ignited fuel at a rate greater than said fuel can react therewith and burning the resultant mixture in contact with limestone.

Signed at New York, in the county of New York and State of New York, this 5th day of December, A. D. 1905.

CARLETON ELLIS.

Witnesses:
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FRED I. SMITH.