

May 21, 1929.

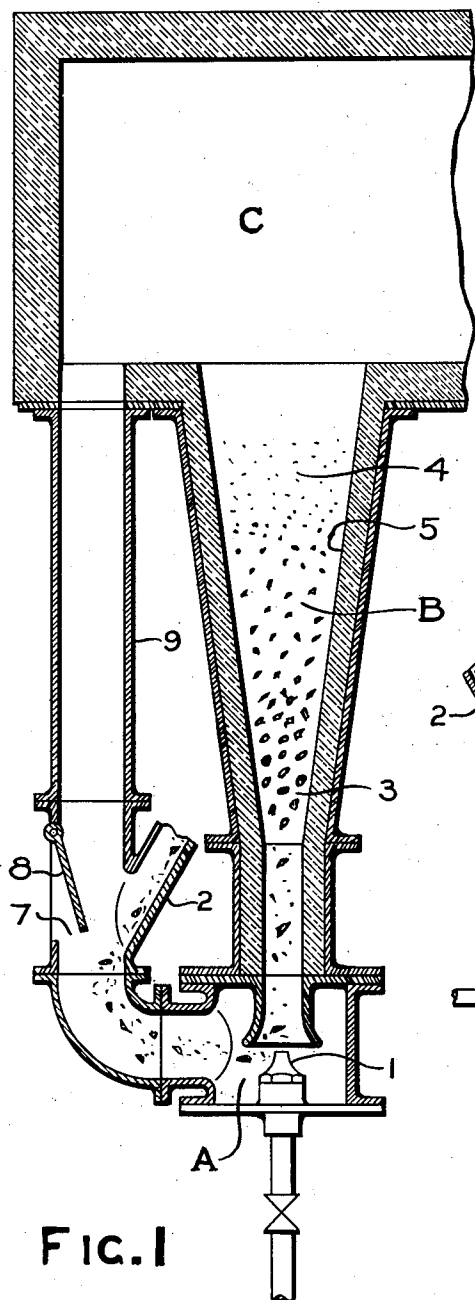
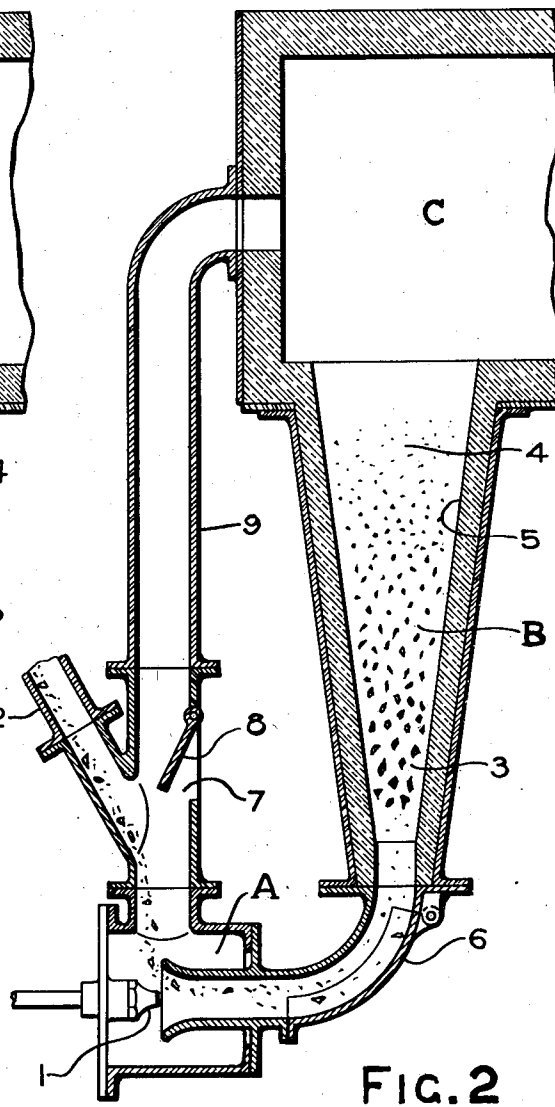
A. COTTON

1,713,817

METHOD OF BURNING SOLID FUEL

Filed Sept. 11, 1922

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

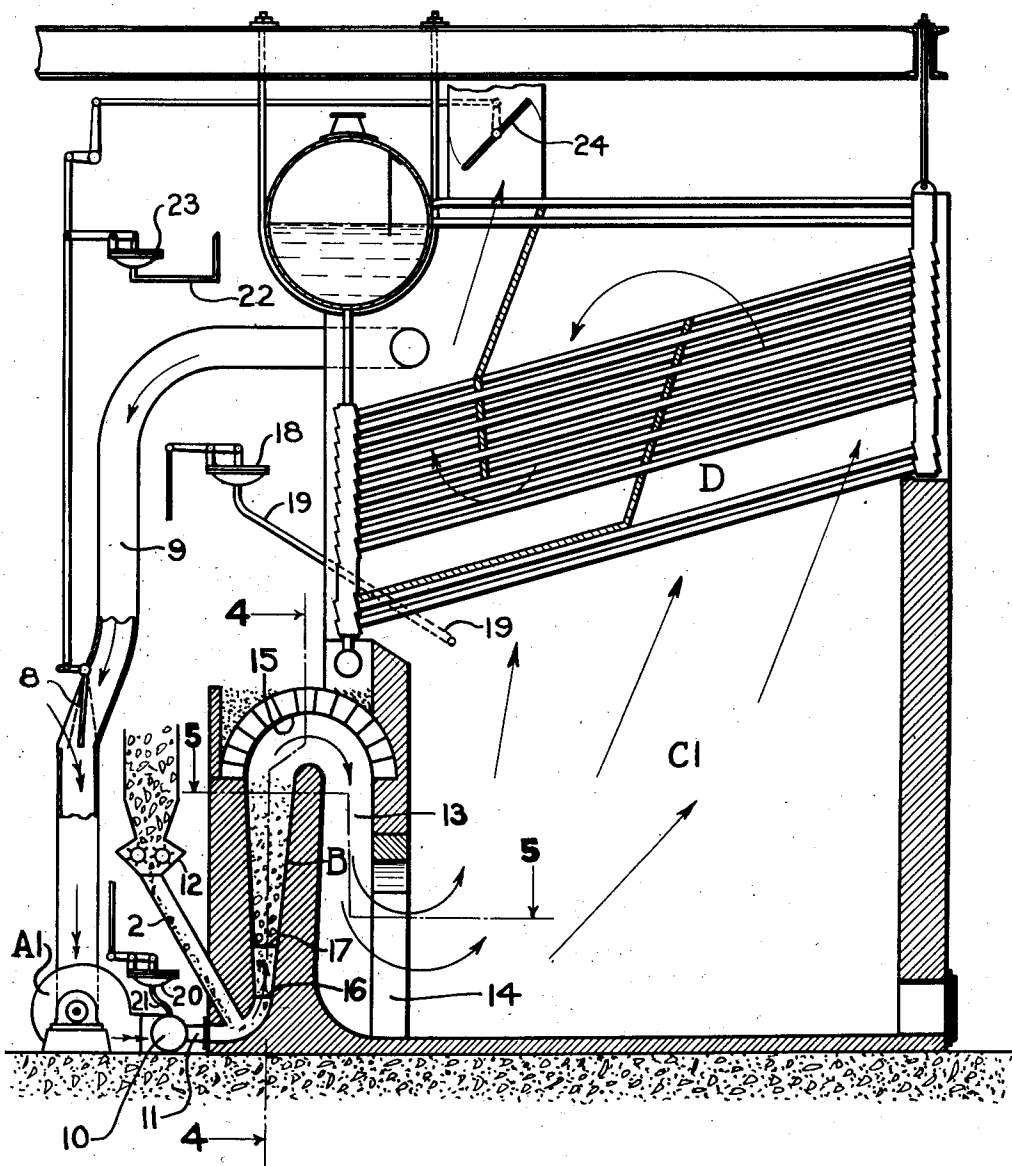


FIG. 3

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3 Sheets-Sheet 3

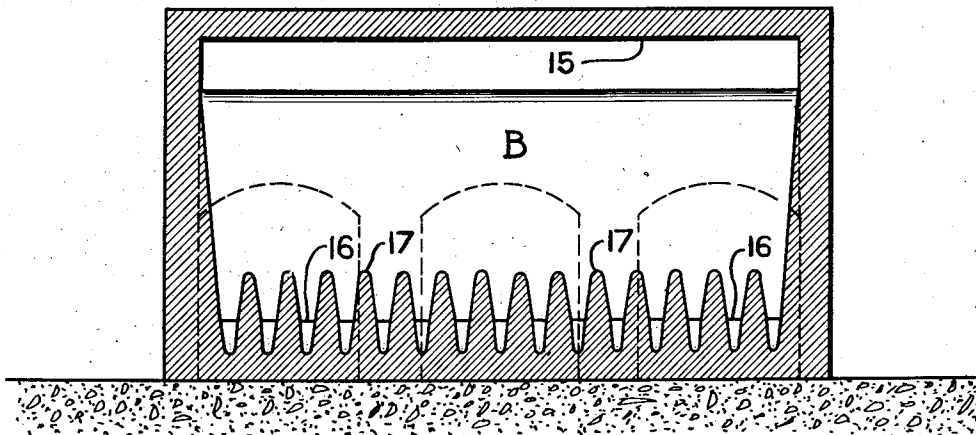


FIG. 4

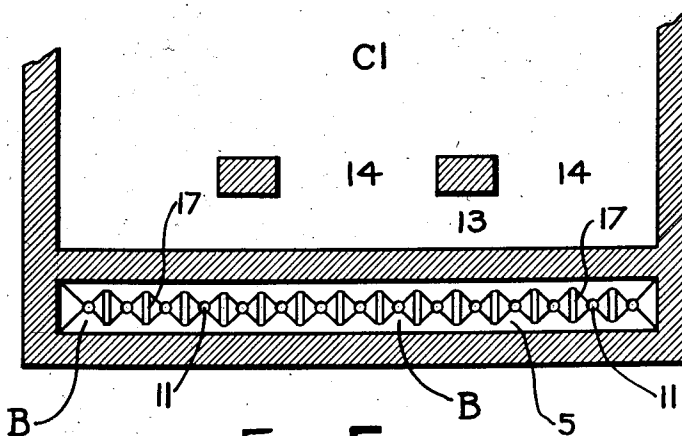


FIG. 5

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UNITED STATES PATENT OFFICE.

ALFRED COTTON, OF ST. LOUIS, MISSOURI; LAURA P. COTTON EXECUTRIX DE BONIS
NON OF SAID ALFRED COTTON, DECEASED.

METHOD OF BURNING SOLID FUEL.

Application filed September 11, 1922. Serial No. 587,295.

This invention relates to methods of burning solid fuel.

One object of my invention is to provide a method by which solid fuel can be burned efficiently in a simple manner without mechanical stokers, grates, pulverizers or driers and by which screenings or other smaller coal can be burned without prior treatment and larger coal needs only to be crushed before burning.

To this end I have devised a method, which, briefly stated, consists in introducing particles of solid fuel into a primary combustion space formed by a tapered conduit, igniting said particles after they have entered said space, and maintaining said particles in suspension in a gaseous supporting medium while they are burning. In the method herein particularly described a stream of fluid containing air is used to introduce the particles of fuel into the conduit that constitutes the primary combustion space and to support said particles while they are burning, and said stream is caused to flow through said conduit in such a manner that the larger particles will automatically assume a position below the smaller particles and all of said particles will move gradually towards the outlet of said conduit at a sufficiently slow speed to insure the combustion air acting on said particles effectively enough to produce rapid and complete combustion of the fuel. I accomplish this desirable result by making the primary combustion space above referred to in the form of a divergent diffuser that is arranged vertically, or substantially so, with its lower end communicating with a duct through which a stream of fluid-carrying particles of solid fuel enters said diffuser. While the particular shape and proportions of the primary combustion space may vary, it is essential that it be of such design that the stream of fluid containing the particles of fuel will slow down upon entering said space and spread out laterally so as to completely fill the primary combustion space, and thereafter will flow through said space without the formation of eddies, thereby causing the particles of fuel to collect in different zones

according to their sizes and to travel in an orderly manner towards the outlet of the primary combustion space. In other words, the diffuser which constitutes the primary combustion space must be of such shape and proportions that the stream of fluid which carries the particles of fuel will not rush upwardly through the center of the diffuser at a high velocity, carrying the particles of fuel at the center of said stream clear up to the outlet of the diffuser and permit the particles of fuel at the outer portion of the stream to split off and drop back to the inlet end of the diffuser, but, on the contrary, will flow upwardly through the diffuser in such a way that the particles of fuel in the outer portion of said upwardly flowing stream will travel at substantially the same speed and in the same direction as the particles of fuel at the center of said stream.

Any kind of fuel in small pieces may be satisfactorily burned by my method and apparatus and the heat generated used in connection with boilers or industrial furnaces, or for any other purpose for which fuel is burned. The apparatus is simple and cheap. The excess air used over that required for perfect combustion may be regulated very closely, ensuring high efficiency and economical operation. The rate of combustion is more quickly and easily controlled than with mechanical stokers. It is more economical than burning pulverized coal because the coal need only be crushed. The cost of the apparatus is much less than either mechanical stokers or pulverized coal equipment.

Figure 1 illustrates a furnace constructed in accordance with my invention.

Figure 2 illustrates a furnace constructed in accordance with my invention of another form.

Figure 3 illustrates a boiler of conventional design equipped with combustion apparatus constructed in accordance with my invention.

Figure 4 is a cross section on line 4-4 of Figure 3; and

Figure 5 is a plan in section on line 5-5 of Figure 3.

Referring to Figure 1 of the drawings, A designates a steam-jet blower and B designates a primary combustion space formed by a tapered conduit or diffuser that discharges into a combustion chamber C. A stream of air is induced to flow through the blower and diffuser into the combustion chamber C by means of the jet issuing from the nozzle 1. Crushed coal is fed through the pipe 2 and is carried forward through the blower into the primary combustion space B by the air current. Owing to the divergent form of said primary combustion space the velocity of said stream of air is reduced as it passes through until it is no longer able to carry the coal. This effect is increased by the lowered density of the gases as they are expanded by heating. The larger pieces of coal require a higher velocity and greater gas density to support them, so that the pieces of coal assume positions within the primary combustion space B wherein the larger pieces stay near the bottom as at 3 and the smaller particles stay near the top as at 4. Also, as the pieces of coal become smaller by burning, they rise higher in the primary combustion space B. While the pieces of coal remain fairly stationary in zones or strata according to their size, the pieces constituting a zone are in constant motion partly owing to slight variations in air velocity and the formation of local eddies, and partly owing to the arrival of new pieces of coal whose acquired velocity in passing through the blower A carries them to a higher point than the air velocity can support them so that they drop back a little. The light ash is finally carried out of the primary combustion space B and deposited in the combustion chamber C.

In operation, the refractory walls 5 of the diffuser or primary combustion space B become highly incandescent causing immediate ignition of fresh fuel, so that combustion is both vigorous and complete.

The divergence of the diffuser B may be varied and the taper need not be constant as shown, but the angle may be wider at the top or bottom as may better suit certain fuels. By constructing the diffuser of metal pipe lined with plastic firebrick as shown it is possible to make combinations of tapers or to alter them from time to time at very small expense. In determining the length and taper of the primary combustion space allowance is made for the great increase in volume of the air due to its becoming highly heated while passing therethrough, and for the obstruction offered by the suspended fuel acting to reduce the effective cross sectional area. Thus, with a temperature of from 2500 to 3000° F. at the upper end of the primary combustion space, the air is expanded to about seven times its entering volume. If it is desired to reduce the ve-

locity at the upper end of the primary combustion space to one-half of the entering velocity, then the area at the upper end would have to be about fourteen times that at the entrance, or a little over three times the diameter at the entrance. The actual proportion between inlet and outlet is governed to some extent by the purpose to which the generated heat is to be applied and the volume and arrangement of the combustion chamber C. In some industrial processes it is highly objectionable to allow unburned fuel to become mixed with the material being heated, and in such instances the primary combustion space must be made longer and of larger diameter at the outlet than where the carrying forward of a little of the unburned fuel is of no moment. Or the combustion chamber C may be made large enough to ensure complete combustion of such unburned fuel before leaving it.

While it is convenient to make the cross section of the primary combustion space circular, its cross section may be square or of any other form provided the proportions are such that the stream of air and products of combustion is generally upwards over the whole cross-section.

The fire may be started in any convenient manner such as by making a fire of pieces of wood in the primary combustion space, gradually increasing the supply of air until said space is highly heated, and then increasing the air supply and feeding coal.

In Figure 2 is shown a modification primarily intended to reduce the total height required by placing the steam-jet blower A horizontal. Other modifications readily suggest themselves to the designer. Owing to the high velocity of the air and fuel, it is desirable to provide an easily renewable wearing back as shown at 6, and this may also be used as a cleaning or access door.

Another important part of my invention consists in taking some of the gaseous products of combustion and passing them through the primary combustion space with the air required for combustion so as to produce a stream of fluid that maintains the particles of fuel in suspension while they are burning. Particularly when it is desired to reduce the combustion rate, and at all times when the fuel is not very small, the volume of air necessary for combustion flowing up the primary combustion space is not sufficient to support the fuel in suspension. The amount of air required for combustion enters through the opening 7 controlled by the valve 8, and this inflow of air together with the constriction caused by the valve 8 governs the amount of gaseous products of combustion drawn through the pipe into the steam-jet blower and forced through the primary combustion space B. The more the valve 8 is opened, the more air enters

through the opening 7, and as the proportion of air to products of combustion entering the space B is thus increased, the more rapid does the combustion become. As the valve 8 is closed allowing less air to enter, the larger proportion of products of combustion entering the primary combustion space B retards combustion of the suspended fuel. This provides a simple, reliable and most effective method of governing the rate of combustion without disturbing the suspension of the fuel.

In my invention it is necessary that the divergence of the walls of the primary combustion space should be sufficiently small to prevent the smaller particles of fuel and dust being carried out of the diffuser unburned to a considerable extent. Therefore this divergence is not much, if at all, greater than that used in diffusers solely intended for the conversion of velocity into pressure. As understood in the art, the expanding gas stream must fill the primary combustion space, and this is not the case with the funnel-like chambers of vortex or fountain furnaces.

But while the primary combustion space of my invention wherein primary combustion takes place differs fundamentally from the combustion chamber of vortex or fountain furnaces, my method of providing an increase in the amount of propelling fluid by adding gaseous products of combustion to the air, is applicable to vortex or fountain furnace also. It is very advantageous in conjunction with such furnaces in providing fluid for propelling the fuel when the air required for combustion is too small for this purpose.

The proportion of air and of gaseous products of combustion entering the primary combustion space may be controlled automatically, and this will be described later together with other automatic controls.

In Figure 3, D designates a cross-drum boiler of conventional design provided with the usual combustion chamber designated by C¹. The diffuser in which primary combustion of the fuel takes place, is designated B. The fan A¹ supplies air under pressure to the main air duct 10, from which branch air ducts 11 convey the air to the diffuser. A coal-crusher 12 discharges coal through the pipe 2 into the branch duct 11. The products of combustion pass from the diffuser down the vertical flue 13 and through the openings 14 into the combustion chamber C¹. A firebrick arch 15 covers the passage from the diffuser to the vertical flue 13. The heat from this arch reflected back into the diffuser raises the temperature therein and thereby aids combustion. The valve 8 controls the proportion of air and products of combustion fed to the diffuser as in Figures 1 and 2, and the pipe 9 conveys the

products of combustion from some part of the boiler setting.

The subsequent downward flow of the gases along the flue 13 and their discharge through the openings 14 as illustrated in Figure 3 is preferable for some boilers and other furnaces, as the gases then pass through the whole of the combustion chamber which allows of more complete deposition of ash.

In a boiler or in any other furnace of considerable width, it is convenient to use several primary combustion spaces or diffusers merged into one as more clearly indicated in Figures 4 and 5. In Figures 3 and 4 the bottoms of the diffusers are at 16, and the dividing walls between the lower part of the diffusers terminate at 17. Above this, the diffusers merge into one elongated chamber, supplied with fuel and air from a plurality of ducts. The action is similar to that with a single diffuser and duct wherein the fuel is held in suspension almost stationary until burned.

In operating this method of combustion in conjunction with a boiler, it is desirable to keep a slight vacuum—about one-tenth of an inch—in the combustion chamber. This vacuum is governed by the rate of flow of the gases from the primary combustion space B into the combustion chamber and by the rate of flow of the gases from the combustion chamber through the boiler. The rate of flow of the gases from the primary combustion space depends upon the quantity of coal therein which resists the flow of the air and gases, and upon the pressure of the air below the primary combustion space. In the arrangement illustrated in Figure 3, the pressure in the combustion chamber C¹ is communicated to the diaphragm motor 18 through the pipe 19, and governs the speed of the coal crusher 12. When the vacuum in the combustion chamber increases beyond the desired amount, the speed of the coal crusher is reduced so that a smaller amount of coal is fed to the primary combustion space. The smaller amount of coal in the primary combustion space offers less resistance and the flow of gases therethrough is increased whereby the vacuum in the combustion chamber is reduced to normal. When the vacuum in the combustion chamber is reduced below normal, the coal crusher is speeded up and the larger amount of coal supplied to the primary combustion space reduces the gas flow and allows the vacuum in the combustion chamber to increase up to its normal amount.

To operate in the manner just described, it is desirable to keep the pressure in the duct supplying the primary combustion space at a constant amount. The diaphragm motor 20 is affected by changes of pressure communicated through the pipe 21, and operates

mechanism which varies the speed of the fan A¹.

When the amount of steam demanded from the boiler D is reduced below normal, the steam pressure therein rises and affects the diaphragm-motor 23 which is connected to the boiler by the pipe 22. The diaphragm-motor then reduces the amount of opening of the damper 24 and moves the valve 8 to the left, reducing the air supply. This results in a smaller proportion of air being supplied to the primary combustion space, and combustion therein becomes slower than the combustion which takes place under normal consumption of steam. With the lower rate of combustion, coal tends to accumulate in the primary combustion space and reduces somewhat the flow of gases which results in a higher vacuum being created momentarily in the combustion chamber. This momentary increased vacuum, acting through the medium of the diaphragm-motor 18, reduces the rate of coal feed to that required to meet the smaller load on the boiler, and thereafter, the combustion in the primary combustion space will occur, as previously described. If the demand for steam is increased, the boiler pressure falls and the diaphragm-motor 23 causes the damper 24 to open wider and the valve 8 to move to the right admitting more air. This reduced vacuum, acting through the diaphragm-motor 18, increases the rate of coal feed as already described.

In an industrial furnace for heating a mass of material, the damper may be directly connected to the valve 8 as in Figure 3, and be operated by hand without the intervention of the diaphragm motor 23. Opening the damper and increasing the air supply reduces the vacuum in the furnace, which increases the coal supply by means of the diaphragm-motor 18. When it is desired to regulate combustion entirely by hand, the pressure in the duct below the primary combustion space is observed, and when it increases, the supply of fuel is reduced and vice versa. The rate of combustion is regulated by opening or closing the valve 8.

The diaphragm-motors 18, 20 and 23 are shown in diagram form and are not described in detail nor are relay-valves or power motors shown as they consist of apparatus in common use. Any form of automatic or hand regulating apparatus may be used.

While I have herein illustrated various forms of apparatus for practicing my method, I wish it to be understood that my invention is not limited to apparatus comprising elements of the particular kind and arrangement herein illustrated and described. My broad idea consists in burning particles of fuel while said particles are maintained in

suspension in a gaseous supporting medium, and various kinds and forms of apparatus can be used for accomplishing this result. It is preferable, however, to use an apparatus comprising a primary combustion space formed by a tapered conduit, herein referred to as a diffuser, but the length, taper and diameter of said primary combustion space may vary greatly. It is essential, however, that said primary combustion space be of such design that the stream of fluid used to support the particles of fuel in the primary combustion space will slow down upon entering said space, will simultaneously spread out so as to completely fill said space, and thereafter will flow in an orderly manner towards the outlet of said space. When the apparatus is constructed in this manner the particles of fuel will be truly maintained in suspension while they are being burned, due to the fact that the weight of each particle of fuel is balanced by its resistance to the flow of the stream of fluid in which it floats; the combustion of the fuel will be complete, due to the fact that an ample supply of combustion air is constantly passing over each particle of fuel, as said particle is traveling upwardly through the primary combustion space; and the combustion of the fuel will be rapid, due to the fact that the air is in rapid motion relative to the fuel, thus causing the products of combustion to be carried away as quickly as they are formed. While I have herein described my method as being practiced in an apparatus which is of such design that a stream of fluid, formed wholly or partly of air, is used to introduce the fuel into the primary combustion space and maintain the fuel in suspension while it is burning, I wish it to be understood that my broad idea contemplates introducing the fuel into the primary combustion space in other ways.

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

1. A method of burning solid fuel, characterized by introducing small particles of solid fuel into a flared, vertically-disposed primary combustion space by means of a flowing stream of combustion air and products of combustion, causing said particles of fuel to be maintained in suspension in said space by said flowing stream while said particles are burning, and varying the proportions of air and products of combustion constituting said flowing stream so as to govern the rate of combustion of said fuel.

2. A method of burning solid fuel, characterized by feeding small particles of solid fuel into a flowing stream composed of air and products of combustion, causing said stream to enter a vertically-disposed primary combustion space of gradually increasing cross-sectional area and flow upward-

ly through said primary combustion space in such a way that it maintains said particles of fuel in suspension while they are burning and moves said particles upwardly 5 through said space towards the outlet of same, varying the relative quantities of air and products of combustion constituting said stream so as to govern the rate of combustion of said fuel and varying the velocity of said stream so as to insure said fuel 10 remaining in the combustion space until it is burned.

ALFRED COTTON.