Nov. 3, 1925. **1,560,076**

E. GATES

METHOD AND APPARATUS FOR COMPLETE COMBUSTION

Filed April 8, 1922 2 Sheets-Sheet 1

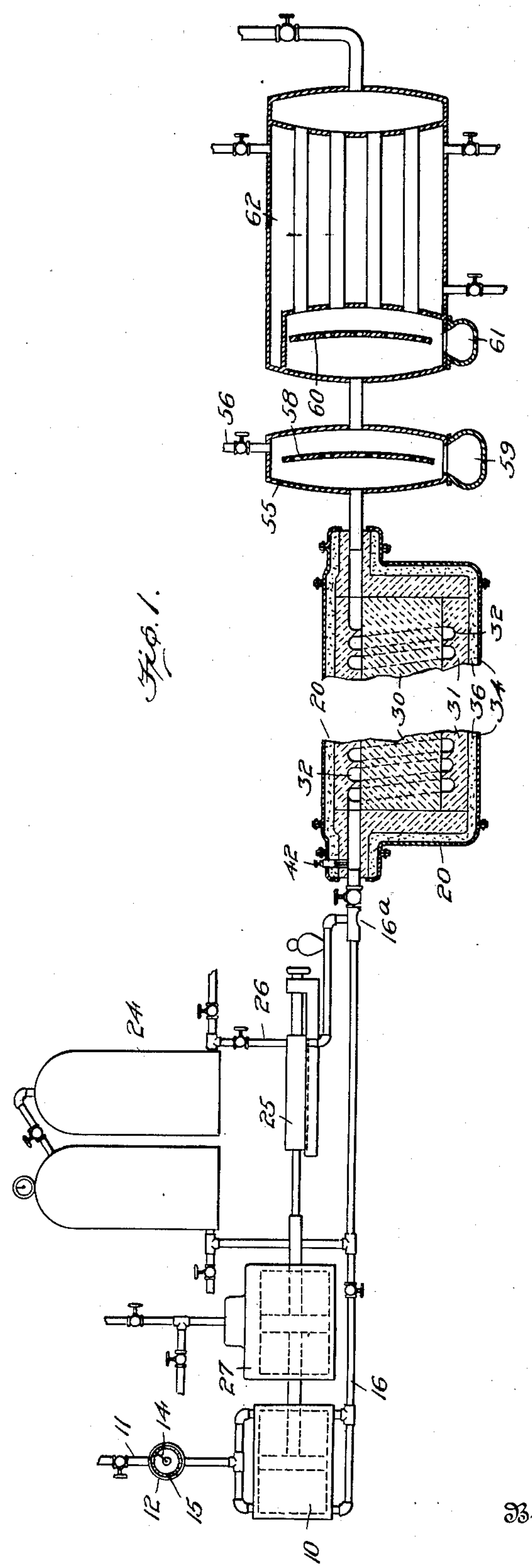

Fig. 1.

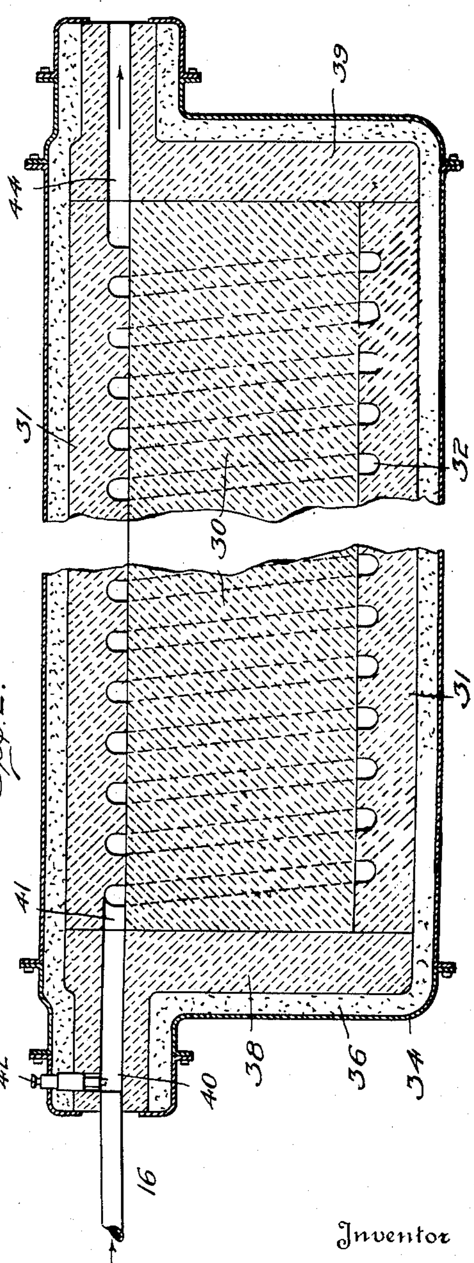

Fig. 2.

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Fig. 3

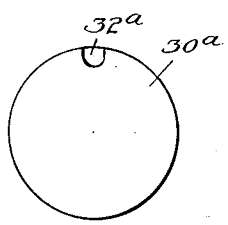


Fig. 4.

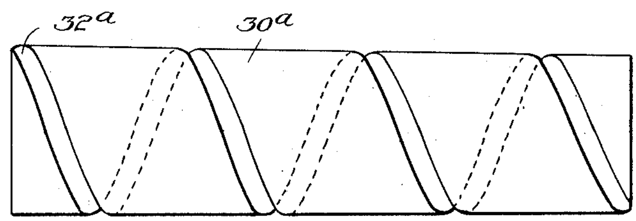


Fig. 5.

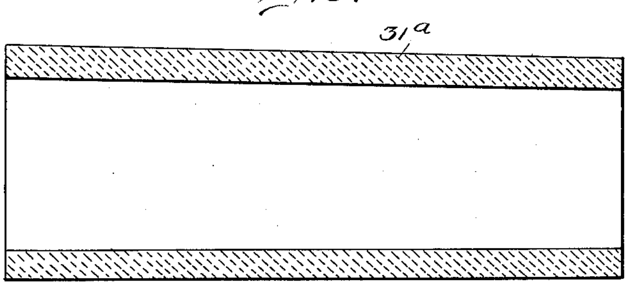


Fig. 6.

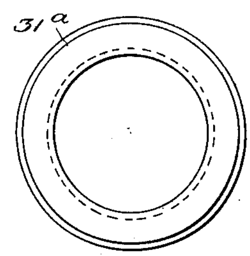


Fig. 7.

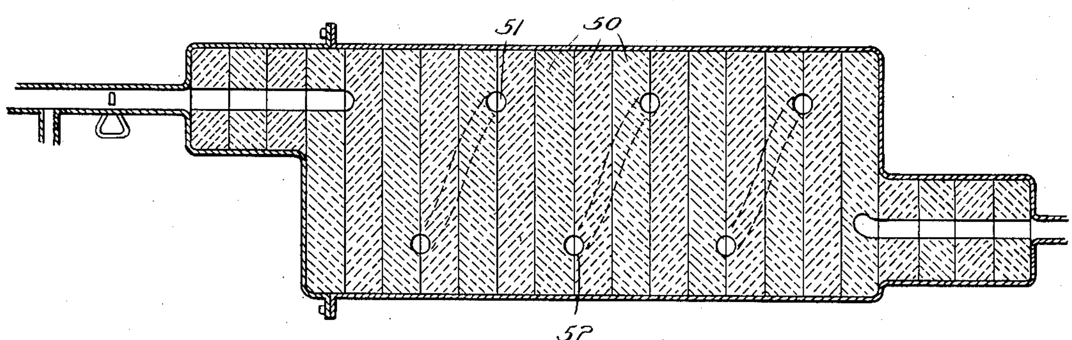
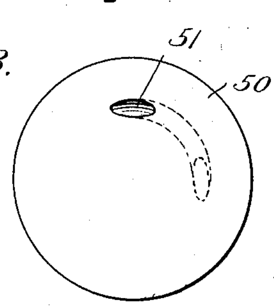


Fig. 8.



Inventor

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His Attorneys

Patented Nov. 3, 1925. **1,560,076**

UNITED STATES PATENT OFFICE.

ELMER GATES, OF WASHINGTON, DISTRICT OF COLUMBIA; DONALD E. GATES ADMINISTRATOR OF SAID ELMER GATES, DECEASED.

METHOD AND APPARATUS FOR COMPLETE COMBUSTION.

Application filed April 8, 1922. Serial No. 550,739.

To all whom it may concern:

Be it known that I, ELMER GATES, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Methods and Apparatus for Complete Combustion; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming part of this specification.

This invention relates to the combustion of fuel either solid or liquid, or a mixture of the two, or a mixture of powdered solid fuel with water, etc., and contemplates the more complete combustion of the same thereby obtaining a considerable higher efficiency than is possible with any of the methods or devices of the present day. The primary object of the present invention is to provide a method of obtaining more heat from a given quantity of fuel by burning all the particles of powdered solid fuels and soot and by more completely burning the gaseous portions that now escape from modern furnaces operated under present methods of combustion.

It is, for instance, a matter of experience that a portion of the aforesaid particles of solid powdered coal fall to the bottom of the present kinds of furnaces or pass up the chimney before being fully burned, that the aforesaid particles of soot pass out of the present kinds of burners and combustion chambers when liquid fuels are being burned, and that still-unburned portions of oxygen and fuel-gases are found in the products of combustion after having escaped into the atmosphere; and it is one of the purposes of the present invention to minimize this waste of fuel by burning more of the solid particles and gaseous portions with a little less air and thereby also getting a little higher initial temperature.

The particles of powdered solid fuels and the particles of soot in liquid fuels and the unconsumed portions of oxygen and gaseous fuel have a greater specific gravity than any of the rest of the burning mixture because the yet-unburned portions of the mixture are cooler and therefore heavier than the burned portions and the burned portions, especially at the moment of burning, are hotter and therefore lighter and may be, to a certain practical extent, separated from each other by their differences of specific gravity if given sufficient time to do so in a long enough combustion chamber the entire inner surface of which is kept incandescent by this combustion so as to re-ignite the unburned portions which, when burned, gravitate away from that incandescent surface.

This separation may also be accomplished, for low temperatures, if the burning gases are made to rotate in a helical chamber which causes them to rotate and by centrifugal force causes the heavier and unburned particles and portions to be thrown tangentially outward against the inner and incandescent surfaces of the cylinder, where they are repeatedly re-ignited, while the burned and lighter portions are displaced inwardly. This centrifugal and centripetal separation of the unburned portions from the burned portions and from the large percentage of incombustible nitrogen and CO_2, may be still more quickly and completely accomplished by causing the burning mixture to flow, at a sufficient velocity through a spiral, tubular, incandescent-surface combustion-chamber, thereby throwing the unburned portions and oxygen together, again and again, and simultaneously igniting them and not allowing the flame-gases to be chilled below their highest temperatures of combustion until the burning has been entirely completed. This centrifugal throwing of these unburned fuels and free oxygen against the incandescent surface of the spiral is maintained for a sufficient time by making the tubular combustion chamber long enough and narrow enough to cause the mixture, of the required volume to do the amount of work intended, to flow at such a velocity that sufficient centrifugal force, at that radius of curvature, will be produced, to do the separating.

It needs to be noted that this is a method of burning under the normal atmospheric pressure of about 14.7 lbs. per square inch with just enough additional pressure to cause the flow of the gases through the system; and it needs to be noted that I am simultaneously filing an application for patent on a method of burning under higher than atmospheric pressures which uses air compressed to half or fourth its normal volume. In this method of burning under normal atmospheric pressures I get a higher initial temperature because by using up all the oxygen in the air less air is needed to burn a pound of fuel and consequently the heat-units in a pound of coal are diffused through a smaller volume of gases; I get more heat from a pound of coal because all the particles are burned, and I lose less heat in the exhaust because by burning with less air a smaller volume of gases escapes up the chimney at whatever temperature they have to escape after doing the heat-work intended.

An apparatus which may be used for carrying out the above-described process is shown as an illustrative embodiment of the invention in the accompanying drawings, in which:

Figure 1 is a diagrammatic view of the entire apparatus;

Figure 2 is a vertical section through the combustion chamber of the type used for powdered solid fuels and fuel-pastes;

Fig. 3 is an end view and Fig. 4 a side view of the core of the combustion chamber.

Fig. 5 is an end view and Fig. 6 a side view of the sleeve of the combustion chamber.

Fig. 7 is a transverse vertical section of another form of combustion chamber;

Fig. 8 is an elevation of one of the blocks shown in Fig. 7.

It should particularly be borne in mind that this invention is not limited in any way to the embodiment shown in the drawings, it being the intention to utilize the process in connection with locomotive boilers, steamer boilers, marine boilers, kilns, house-heating, aircraft, ore-reduction, and in many other ways.

In the embodiment shown, 10 is an air-pump or compressor receiving air through pipe 11 in which is located a valve 12 having an arm or pointer 14 which moves over a graduated scale 15 so that the valve may be set for any given volume or speed of pumping. The pump 10 delivers air through the pipe 16 to the combustion-chamber 20. The fuel may be liquid, as for example, such a hydrocarbon as crude oil or gasoline, or alcohol, or it may be a finely powdered fuel, but it is preferably a mixture consisting of a powdered solid fuel made into a paste with sufficient liquid fuel or water or any other liquid so as to be of a consistency that will flow as freely as certain of the fuel oils when under a relatively heavy pressure and through pipes of slightly larger caliber than is customary.

The fuel tank 24 feeds by gravity or otherwise through the pipe 26 to the fuel pump 25 and is delivered by said pump to pipe 16 at a point 16ª where the air and fuel make a spray before entering the combustion chamber. The air pump and the fuel pump may be driven in any preferred manner, the specific type forming no part of the present invention. In the drawings, I have shown both of these pumps directly connected to a steam motor 27 and have illustrated the fuel pump as being independently adjustable so that with any given stroke of the steam motor the supply of oil or other fuel may be regulated independently of the air supply.

The combustion chamber 20 is formed of the best procurable kind of refractory, the condition of use being that the temperature of combustion must be regulated so that it will not rise above the point at which the refractory will begin to soften, the efficiency being greater the higher the melting-point of the refractory.

In Fig. 2 is illustrated the combustion chamber that is more particularly adapted to burning powdered solid fuels made into a paste. The core 30 is cast in cylindrical shape and over it is fitted a sleeve 31 which is internally grooved as at 32 so that when assembled with the core it provides a helical passageway. It has been found that the incandescence of the passageway can be more quickly established by coating the inner surface of this groove with a thin layer of cerium oxide which is readily applied by saturating the groove wall with cerium chloride and then converting the chloride into the oxide by the application of heat in the presence of air.

For burning at atmospheric pressures and for obtaining about half the theoretical efficiency, I do not allow the furnace to produce its highest temperature but only such a temperature as the best procurable refractory will withstand.

A steel casing 34 surrounds the refractory material, but is spaced from the sleeve 31 by a filler 36 of carbon to which is added a small amount of zirkite. The combustion chamber has at its ends headpieces 38 and 39, the former being the entrance head and having a passageway therethrough, the outer portion 40 to receive the fuel supply pipe 16 being straight, but the passage curving at its inner end 41 so as to direct the incoming fuel and air tangent to the helix 32 formed by the core and its sleeve.

A spark plug 42 or other igniting means is located within the entrance head 38 so that a portion at least of the incoming and sprayed fuel shall be burning at the time it strikes the initial end of the helix. The rear head 39 has a passageway 44 communicating with the exit end of the helix and a mouth parallel to the axis of the combustion chamber. It should be noted that the passageways 40 and 44 are spaced some little distance from the edges of the steel casing 34.

In Figs. 3 to 6, I have shown a modification of the combustion chamber which is more particularly adapted to the burning of liquid fuels, for they require a shorter passageway, the slightly-conical core 30[a] having a groove 32[a] cast on its outside and being slipped into a slightly conical sleeve 31[a].

In Figs. 7 and 8 is shown a modification of this same device which is made by assembling a number of disks 50 each of which has a curved hole 51 through it, in such a manner that when the disks are properly assembled a spiral or rather helical passageway 52 will be formed through the disks.

The operation of the device is as follows: The fuel and air are pumped into the tubular combustion chamber through the spraying device, there being just enough air to supply sufficient oxygen to burn the fuel, the spraying taking place in a slightly enlarged entrance of the chamber and ignited by an electric spark plug. This mixture of fuel and air while burning expands to six or eight times the volume of the mixture considered as a gas and the burning fuel passes through the entire length of the helix at a considerable velocity which varies in accordance with the rate of pumping the air and fuel. After ignition the inner surface of the tubular passage is almost instantly rendered incandescent and kept so and the unburned particles of fuel and oxygen are repeatedly thrown against this incandescent ignition-surface by centrifugal action until every particle and portion has been burned and then the hot gases allowed to pass to a steam boiler or a motor, or the vanes of a turbine, or objects in a kiln.

The walls of the corkscrew-shaped tubular combustion chamber are made of the best procurable refractory substance and the caliber of the tube is such that when a sufficient volume of flame gases is flowing through to do the amount of work intended it must flow at sufficient velocity to give enough centrifugal force to pick out from the burning mixture of oxygen and incombustible nitrogen and carbonic dioxid, the yet-unconsumed oxygen and fuel, and at the same time centripetally displace inwardly (towards the axis of revolution) the burned and lighter gases, giving a slightly greater excess of oxygen at that part of the inner periphery of the spiral which is farthest from the axis of the spiral and causing more heat units to be created in a smaller volume of of the total products of combustion and giving a higher initial temperature.

No burning or oxidation takes place against the boiler tubes, hence they may be somewhat thinner than usual, and the flame, not being chilled below the temperature of combustion until combustion has been completed, will deposit no soot on the boiler tubes, thereby making them more absorptive of heat and not clogging the flues, etc. These completely burned flame gases, if the temperature is not allowed to rise too high, may be used in locomotive boilers of the present kind, in steamer automobiles, marine boilers, kilns, etc., aerial motors, turbines, etc., but before going into a boiler the ash settler as shown in Fig. 1 should be used. The ash settler 55 has a pipe 56 for injecting air to cool the products of combustion down to a temperature where they may be directed against the boiler tubes, of course, with a loss of efficiency. The baffle plate 58 within the ash settler 55 is perforated so as to cause the gases to flow equally through the flues and to direct any ash that may be present in the gases to the the ash receptacle 59 forming the bottom of the ash settler. It is found advantageous to add a second baffle plate 60 and ash receptacle 61 in the front end of the boiler indicated at 62.

What I claim is:

1. The method of obtaining a more complete combustion of finely divided fuel which consists in passing the burning fuel through a helical passageway, said passageway being bounded by incandescent walls whereby the passage of the fuel through the helical passageway will cause the unburned portions of fuel to be thrown into repeated contact with the incandescent walls of the helical passageway.

2. The method of obtaining a more complete combustion of finely divided fuel, solid or gaseous, which consists in passing the burning fuel at a high velocity through a helical passageway of a plurality of turns bounded by incandescent walls whereby the high velocity of the fuel will cause the unburned and consequently heavier portions of the fuel to be thrown outwardly by centrifugal force against said incandescent walls, igniting said unburned portions.

3. The method of obtaining a more complete combustion of a finely divided fuel which consists in passing the burning fuel at a high velocity through a helical passageway of any given radius of curvature and of a plurality of turns bounded by incandescent walls whereby the velocity of the fuel will give centrifugal force to cause the unburned and consequently heavier portions of the fuel, to be thrown outwardly against said incandescent walls, igniting and reigniting said unburned portions until all the unburned portions are burned.

4. The method of obtaining a more complete combustion of powdered solid fuels which consists in passing the burning mixture of fuel and air through a helical passageway, said passageway being bounded by incandescent walls whereby the passage of the fuel through the passageway will cause the unburned portions of fuel and oxygen to be thrown repeatedly into contact with the said incandescent walls and reignited and all of them burned.

5. The method of obtaining a more complete combustion of all of a finely divided fuel which consists in passing the burning fuel and air at a high velocity through a long helical incandescent passageway of a plurality of turns causing the unburned and consequently heavier particles to be thrown outwardly against said walls and igniting and re-igniting the said unburned portions until there are none left in the escaping gases.

6. The method of obtaining a more complete combustion of finely divided fuel which consists in passing the burning fuel through a helical passageway bounded by incandescent walls, said passageway being composed of a number of turns.

ELMER GATES.