

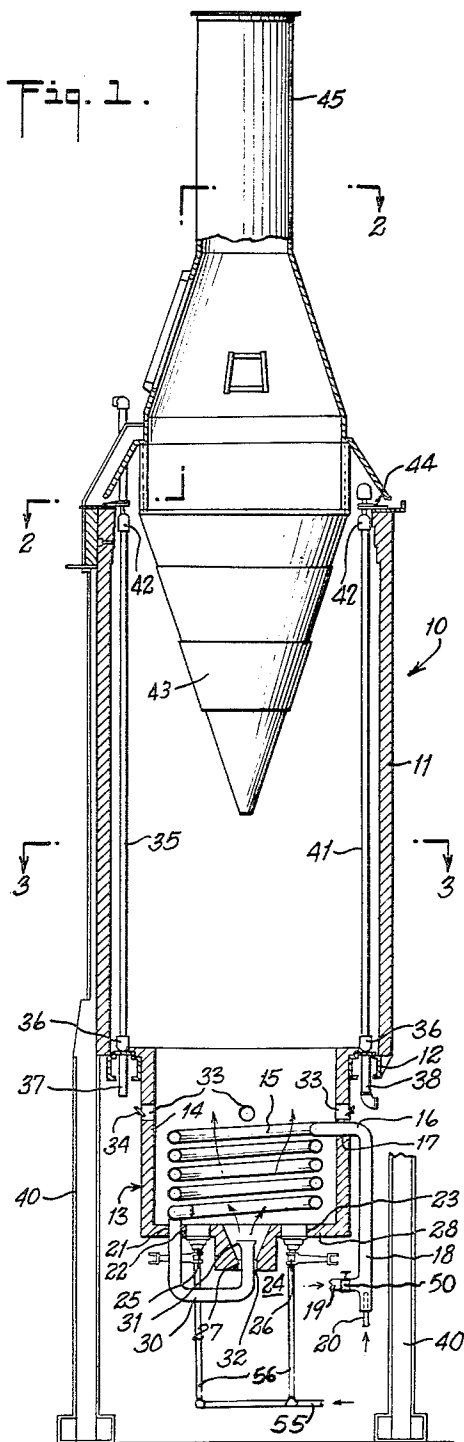
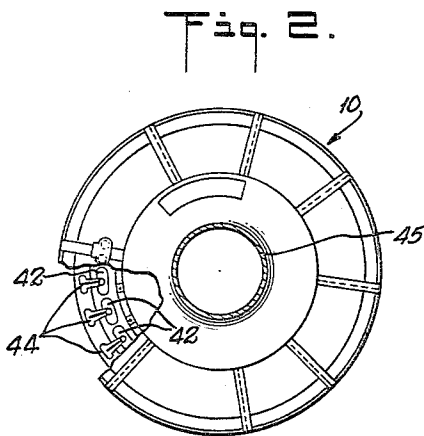
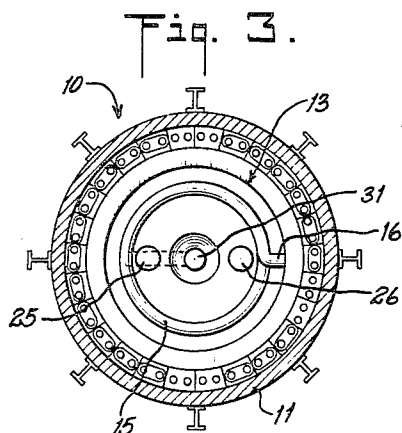
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METHOD AND APPARATUS FOR BURNING LOW VOLATILE FUEL

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METHOD AND APPARATUS FOR BURNING LOW VOLATILE FUEL

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2 Claims. (Cl. 110—22)

This invention relates to a vertical tube heater having a tall cylindrical furnace chamber and a cylindrical bank of vertical heat exchange tubes near the walls of the furnace chamber and spaced therefrom.

One object is to provide a furnace of this type with a novel primary combustion chamber for burning effectively and efficiently low volatility fuel such as finely divided petroleum coke, which is known to be highly refractory, anthracite coal and other carbonaceous materials.

The utilization of fuels of such characteristics has heretofore been very difficult and according to this invention, the finely divided coke particles, or the like, are first combined with steam under such conditions that temperatures of 1200° F. to 1600° F. are reached. A well known water gas reaction is thus effected or at least partially obtained, thereby producing a gaseous product largely composed of CO, and when this stage of the reaction is reached, air or other oxygen bearing gas is preferably introduced into the hot effluent products in a primary combustion chamber in a unitary heater to insure the combustion of the CO, which is thus converted to CO₂ and the combustion of any reacting carbonaceous material. The hot products of combustion then pass upwardly in an axial direction through the cylindrical bank of heat exchange tubes to which heat is thus applied largely by radiation, and the flue gases pass out at the top of the furnace. Thus the advantages of this water gas reaction and a final radiant furnace heater are combined in one compact unit.

Transportation necessities may make it desirable to combine the finely divided solid carbonaceous material with heavy fuel oil, or other hydrocarbon liquid, to insure fluidity and make the mixture susceptible of being pumped through a pipe line.

This invention comprises the following steps: combining solid carbonaceous material in a finely divided form with steam, heating these combined substances to a temperature sufficient to maintain chemical reaction, discharging the product, while hot, through a burner nozzle, where air or other oxygen bearing gas is introduced so as to insure the complete combustion of the non-volatile fuel material and the gaseous material resulting therefrom in a heater where the heat is effectively absorbed. This procedure is not changed substantially when the finely divided carbonaceous material is first mixed with heavy fuel oil or other hydrocarbon liquid.

Reference may now be had to the drawings, in which:

Fig. 1 is a sectional elevation of a complete heater which embodies the preferred apparatus of this invention and which is particularly well adapted for carrying out the method of this invention;

Fig. 2 is a plane view partially in section taken along the line 2—2 of Fig. 1;

Fig. 3 is a plane view partially in section taken along the line 3—3 of Fig. 1.

Referring to the drawings, the vertical tube heater illustrated comprises a cylindrical metal shell 10, having

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a lining 11 of fire brick, or the like, mounted on an annular box beam support 12, from which depends a primary combustion chamber 13 of somewhat smaller diameter than the metal shell 10. The space within the shell 10 constitutes the secondary combustion chamber and may be considered as a part of the primary combustion chamber.

The primary combustion chamber 13 is preferably formed with steel walls and has a heavy refractory lining 14. Located within the primary combustion chamber is a helical coil 15, which is co-axial with the chamber and its coils are located near the refractory lining of the walls of the primary combustion chamber 13, thus forming an open cylindrical chamber with coils near its walls.

The coil has an entrance lead-in pipe 16 which extends through an opening 17 from the side of the combustion chamber and is supplied by a feed line 18. This line is constructed at its lower end with a T forming an inlet 19, into which the finely divided fuel, with or without an admixture of fuel oil or the like, is introduced, and the lower end of the pipe 18 constitutes a jet and has a steam inlet nozzle 20 projecting into the end of the pipe so as to draw the fuel into the inlet 19 when steam is charged through nozzle 20. The inlet 19 may be closed by a valve 50.

The bottom 28 of the combustion chamber 13 has a passage 21 through which the lower end of the coil 15 projects. A central burner 24 comprises an annular block having a central opening 27 and upwardly and outwardly flaring sides. This is preferably made of steel and lined with refractory material, and is preferably mounted in the center of the bottom plate 28 of the combustion chamber 13.

The lower end of the coil 15 extends downwardly through the opening 21 in the bottom plate and has a U bend so that the inner end of the U bend constitutes the nozzle of the burner 24 and extends upwardly through the opening 27 and has a flaring end 31 within the burner block.

The hole 27 in the burner block is large enough so that an annular air inlet 32 is provided around the burner end of the U bend 30 to permit air to enter.

About two-thirds of the way up on the side walls of the combustion chamber 13, are preferably located inlet holes 33 and each of these has an adjustable damper 34 to control the introduction of air at these points.

A vertical tube heater coil 35 having return bends 36 is mounted on the annular box beam 12 which constitutes not only a support but also protects the inlet and outlet connections of the coil which extend downwardly through holes in the top of the ring 12, as shown at 37 and 38. These connections are outside of the primary combustion chamber 13, which is of small diameter as already described.

The entire structure is supported by legs 40, which are welded or otherwise secured to the shell 10 and extend downwardly a sufficient distance so that workmen may have head room below the combustion chamber 13.

The vertical tube heater, as illustrated, is of radiant type and has no convection section, although the combustion chamber 13 would be applicable also to a vertical tube heater of the combined radiant and convection type such as that shown in our Patent No. 2,340,287, issued February 1, 1944.

The combustion chamber 13 and the burner 24 from which the flame and hot gaseous products resulting from burning the products of the water gas reaction or partial water gas reaction are discharged upwardly at very high temperature, constitute the heater for the entire furnace, and the hot gases proceed upwardly in an axial direction within the shell 10 and within the coil 35, which is composed of a cylindrical bank of radiant tubes 41,

The combustion continues as the flame and hot gases pass upwardly through the secondary combustion chamber of the heater, air being added as necessary through holes 33.

This particular invention is not limited to the details of the vertical tube heater, but the preferred form illustrated comprises a conical baffle 43 which is hung from the top of the heater and extends downwardly a substantial distance within the coil 35. The tubes 41 have the usual return bends 42 at the top and are supported by brackets 44.

In this way the gases from which heat has been extracted by radiation to a substantial extent by coil 35 are finally discharged into the usual stack 45.

The method of effectively starting the heater when cold is as follows:

The valve 50 in the finely divided fuel inlet pipe 19 is closed and steam is introduced through nozzle 20 and flows through the fuel heating coil 15 at the same time auxiliary burners 25 and 26, which are located one on either side of the main burner 24 and are supplied with a volatile fuel from an auxiliary source 55 through pipes 56, raise the temperature inside the coil and of the steam to that required for the water gas reaction, whereupon the valve 50 is opened and powdered fuel is ejected with the steam into the coil 15. As soon as the fuel is converted by the water gas reaction largely to gaseous CO, the main burner 24 is ignited and the auxiliary burners 25 and 26 may be shut off.

Thereafter the main burner (and the auxiliary burners if left on) continues to discharge upwardly an extremely hot flame which is largely free from soot or carbon, and this flame passes upwardly through the coil 15 and imparts heat thereto, but the combustion continues as the flame and hot gases pass upwardly through the vertical tube heater, which we have for convenience in this case called the secondary combustion chamber.

Our invention has the outstanding advantage of first combining finely divided solid or mixed fuel with steam at temperatures of about 1500° F. or higher, thereby producing water gas largely composed of CO by well known chemical reactions and then immediately burning the water gas, which is already at a high temperature, to produce a combustion which gives CO₂ as a final product. The arrangement is such that the hot gases of the final combustion supply heat to partially maintain the first reaction and continue upwardly through the radiant heating chamber of the vertical tube furnace.

This application is a continuation-in-part of our application Serial No. 534,053, filed September 13, 1955, now abandoned in favor of this application.

What we claim is:

1. A vertical tube heater comprising a tall cylindrical furnace chamber, a cylindrical bank of vertical heat exchange tubes close to the inner wall of the furnace chamber but spaced therefrom, a flue gas outlet at the top of the furnace chamber, a gas generating unit constituting a primary combustion chamber which is centrally located at the bottom of and is connected to the tall cylindrical furnace chamber and discharges axially into the same, a

helical fuel heating coil within said primary combustion chamber, a lead-in pipe connected to one end of said coil, an ejector in said lead-in pipe, means for supplying non-volatile finely divided fuel either alone or in admixture with volatile liquid fuel into the lead-in pipe, means for supplying steam to the ejector to force the fuel through the helical fuel heating coil, means for maintaining the fuel and steam in the coil at a temperature sufficient to effect a water gas reaction, a burner nozzle connected to the outer end of the fuel heating coil and discharging centrally within the coil through the primary combustion chamber and axially into the furnace chamber, means for supplying oxygen bearing gas to the primary combustion chamber near the burner nozzle to convert the water gas products to CO₂, means for supplying oxygen bearing gas in regulated quantities into the preliminary combustion chamber beyond the inlet end of the coil to control the final burning of the water gas products and at least one auxiliary burner located beside the main burner, connected to an independent source of volatile fuel whereby the auxiliary burner alone may be used for bringing the fuel heating coil up to temperature before the non-volatile fuel is introduced.

2. A vertical tube heater comprising a tall cylindrical furnace chamber, a cylindrical bank of vertical heat exchange tubes close to the inner wall of the furnace chamber but spaced therefrom, a flue gas outlet at the top of the furnace chamber, a gas generating unit constituting a primary combustion chamber which is located at the bottom of and is connected to the tall cylindrical furnace chamber and discharges into the same, a fuel heating coil within said primary combustion chamber, a steam ejector for forcing finely divided non-volatile fuel with steam into the introductory end of said heating coil, means for maintaining the fuel and steam at a temperature sufficient to effect a water gas reaction in the heating coil, a main burner nozzle connected to the outlet end of the heating coil and discharging centrally within said coil, and means for supplying oxygen bearing gas to the primary combustion chamber near the burner nozzle, two auxiliary burners, one on either side of the main burner, connected to an independent source of volatile fuel, whereby the auxiliary burners alone may be used for bringing the coil up to temperature before the non-volatile fuel is introduced.

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