

[54] DUAL PULSE-JET SYSTEM FOR THE COMBUSTION OF HIGH ASH FUEL

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[58] Field of Search 110/28 R; 122/24; 60/39.77; 431/1, DIG. 8

[56] References Cited

UNITED STATES PATENTS

3,185,871	5/1965	Bodine, Jr.	60/39.77
2,925,069	2/1960	Terpe.	431/DIG. 8
3,606,867	9/1971	Briffa.	122/24

FOREIGN PATENTS OR APPLICATIONS

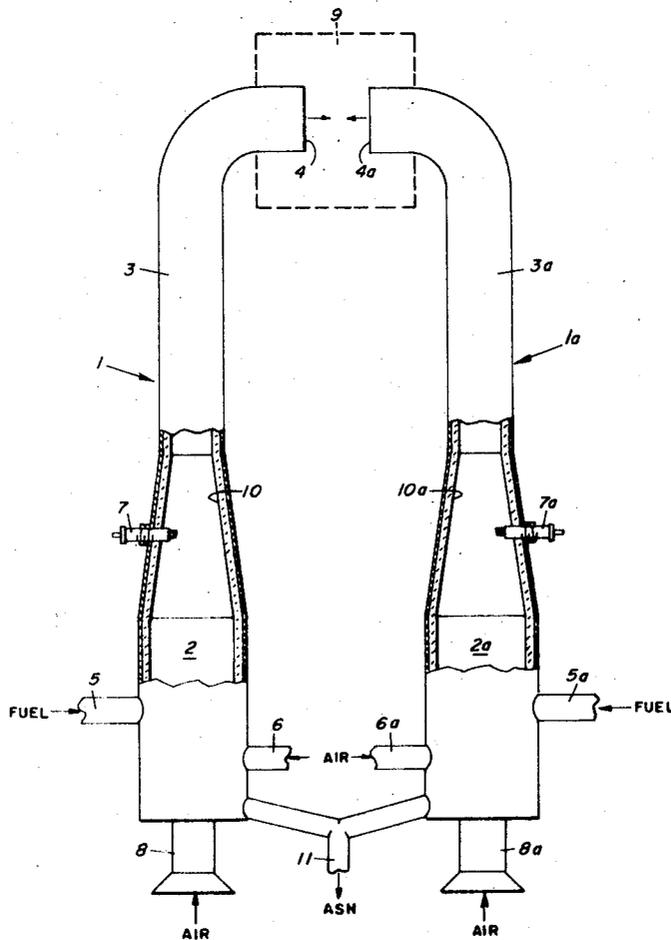
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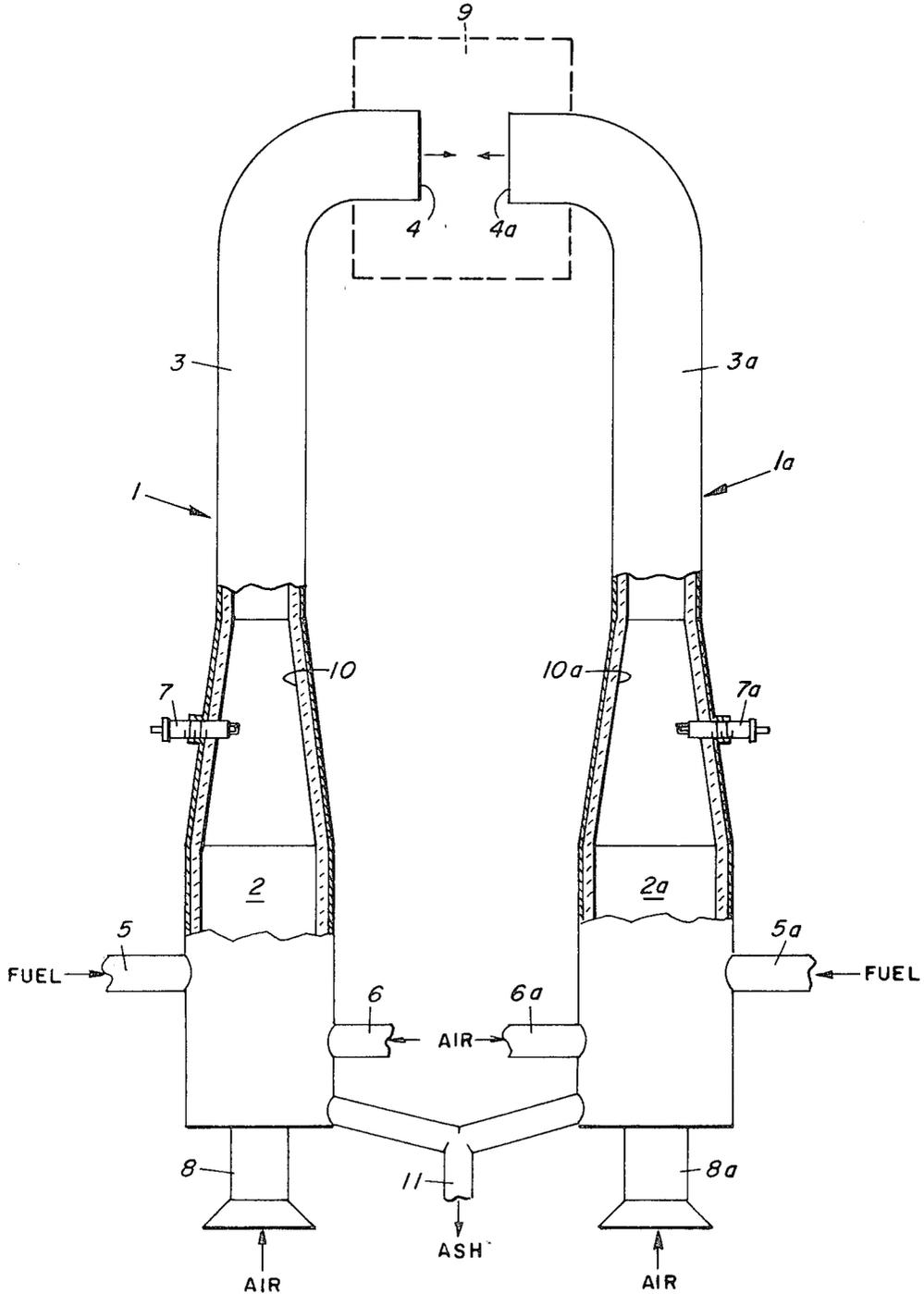
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[57] ABSTRACT

Coal is burned in vertically oriented, dual opposed pulse-jets. Each jet's combustion chamber upwardly discharges combustion gases through a vertical tailpipe bent at its upper end in the direction of the pipe on the adjacent jet so as to allow combustion gases to propel back and forth between the adjacent tailpipes. Combustion air is drawn upward through the bottom of each combustion chamber through a centrally located conduit. Refractory material lines the walls of the jets so as to maintain the average gas temperature above the melting point of fuel ash. Entrained ash in the combustion gases is caught on the walls of the pipes and combustion chambers, and drains down the walls as a molten slag to the bottom of the jets.

5 Claims, 1 Drawing Figure





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DUAL PULSE-JET SYSTEM FOR THE COMBUSTION OF HIGH ASH FUEL

This invention relates to the combustion of carbonaceous or cellulosic solid materials such as coal, lignite, wood, sawdust or garbage.

To abate air pollution, efforts are continually being made to minimize the amount of ash which is discharged into the atmosphere during the burning of solid fuels such as coal in power generation systems. Modern combustion systems currently in use for their ability to retain ash are the cyclone burners. These cyclone systems, however, require powerful air blowers to "spin" the ash dust out of the product gas. Such blowers must be operated at set speeds to attain dust removal which thereby narrowly limits the range of heat release over which the cyclone burners can operate.

In the present invention the fuel burner generally consists of a dual pulse-jet engine system. The two engines are vertically disposed and positioned side by side. Hot combustion gases are discharged upwradly through the tailpipe of each engine, and combustion air is drawn in centrally through the bottom of each combustion chamber. Each tailpipe at its upper end is bent in the direction of the pipe on the adjacent engine so that the exit openings in the pipes are opposite one another whereby exhaust gases propel back and forth between the pipes.

In dual pulse-jets very high temperatures are attained at peak temperature points or nodes along the path of travel of the pulsating gases through the system, which temperatures are considerably above the melting point of the fuel ash. So that the average temperature of the gases in the engines is above this melting point, the tailpipes and combustion chambers are lined with suitable refractory material. This essentially maintains the interior wall surfaces of the tailpipes and combustion chambers at a temperature above the melting point of the fuel ash.

In addition, the design of the system is such that entrained ash in the combustion gases frequently collides with the interior surfaces of the walls of the tailpipes and combustion chambers where it is retained as a molten slag on the refractory lining, which slag then drains downward along the walls. Additional entrained ash particles, both solid and liquid, subsequently collide with and are captured by the slag on the walls. Eventually the slag is drawn off from the bottom of each combustion chamber in the peripheral area of the bottom wall.

A detailed description of pulsating combustion is given in "Pulsating Combustion, the Collected Works of F. H. Reynst," edited by M. W. Thring, Pergamon Press, 1961. On pages 27 and 86 of this book a dual pulse-jet system is shown wherein two single pulse-jet tubes or engines of the same dimensions and configuration are located with the open end of their respective tailpipes positioned so that the gases being expelled by one pipe pass into the other pipe. Under this arrangement the jets will automatically work in opposed phase, i.e., one tube has an explosion while the other is drawing in air whereby the tubes reinforce the pulsations of each other. As used throughout the specification and claims, the phrase "dual pulse-jet" or "dual opposed pulse-jet" refers to such a system. These systems are also disclosed in U.S. Pat. No. 2,796,735.

It is therefore an object of the present invention to burn carbonaceous or cellulosic solids while producing a minimum amount of ash in the flue gas.

Another object is to generate steam for power production in a dual pulse-jet combustion system.

A still further object is to retain molten ash on the interior surfaces of such jet engines.

Other objects and advantages will be obvious from the following more detailed description of the invention taken in conjunction with the drawing which shows a schematic cross-sectional view of the system of the present invention.

Referring to the drawing, reference numerals 1 and 1a designate two essentially identical, vertically disposed, side by side, pulse-jet engines having vertically elongated combustion zones or chambers 2 and 2a, respectively. Tailpipes 3 and 3a extend upwardly from the combustion chambers and define narrow vertically elongated gas flow channels. At the upper end of each channel the tailpipe extends in the direction of the pipe on the adjacent engine so that the pipe exit openings 4 and 4a are opposite one another. Under this arrangement hot combustion gases propel back and forth between the flow channels.

To begin operation, a suitable start-up fuel such as propane, gasoline, fuel oil, natural gas, etc., is injected into the combustion chambers through conduits 5 and 5a while compressed start-up air is injected into the chambers through conduits 6 and 6a.

Ignition devices 7 and 7a, such as a spark plug in each chamber, ignite this air-fuel mixture. Solid fuel such as particulate coal, lignite, sawdust, wood or garbage is then fed through fuel conduits 5 and 5a by, for example, a screw conveyor. Self-sustained pulsating combustion is thereafter carried on in the prior art manner in each pulse-jet as combustion air is drawn into the combustion chambers during each suction cycle through conduits 8 and 8a which are coaxially aligned with the vertical axes of their respective combustion chambers 2 and 2a. As stated above, tuning of the opposed pulse-jets is automatic whereby one jet is exploding and expelling gases as the other is drawing in gases including combustion air.

A vessel 9 such as a steam generator, gas turbine, or heat exchanger can be located at or adjacent the juncture between the ends 4 and 4a of the tailpipes so as to utilize the net flow of hot gases from the jets.

The arrangement of the system of the present invention allows a high degree of contact between entrained ash particles and the interior surfaces of the walls of the apparatus. With regard to the walls or boundaries of the combustion chamber itself, it is believed that such contact is brought about by the central positioning of the air intake tube which appears to create a laminar flow ring vortex pattern within the combustion chamber during air intake. Furthermore, during combustion, residual radial velocities appear to persist in the chamber. Such flow patterns drive entrained ash particles into contact with the chamber boundaries or walls. In addition, the double elbow juncture of the tailpipes contributes to contact of ash with the pipe walls. That is, entrained ash in the combustion gases is alternately projected from one pulse-jet into the other thereby increasing the probability of wall collision.

By lining the interiors of the jets (combustion chambers and tailpipes) with a refractory material, the high probability of ash-wall contact is utilized to trap the

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ash. That is, as explained above, pulsating combustion or carbonaceous or cellulosic solids creates "hot spots" in the system well above the melting point of the fuel ash. So that the average temperature in the system is above this melting point, a continuous refractory lining 10 and 10a is provided in engines 1 and 1a, respectively. This essentially produces temperatures above the ash melting point on the surface of the lining. In this manner, entrained ash which collides with the interior wall surfaces of the jets is caught and maintained as a molten slag. Such captured slag resides in the stagnant gas film boundary layer of the high velocity pulsating gas flow, whereby the slag is essentially unaffected by the net upward gas flow, and will drain by gravity down the walls of tailpipes 3 and 3a, down the walls of the combustion chambers 2 and 2a, and out the chambers through conduit 11 to a suitable collection vessel. As the slag drains downward through the system, it captures additional ash particles (solid or liquid), which collide with the walls.

In order for ash particles or droplets to escape from the system, they must avoid many opportunities for capture by the liquid ash on the walls of the combustion chambers and tailpipes.

Compositions suitable for fabricating linings 10 and 10a will be obvious to those skilled in the art. Exemplary materials include insulating concrete and castable refractory insulation composed of, for example, alumina.

In tests to date with (a) a 35 foot single, refractory-lined pulse-jet and with (b) small scale dual, pulse-jets (each of the dual pulse-jets being similar to the one described in "International Coal Preparation Congress," Fifth Congress, Pittsburgh, Pa., Oct. 3-7, 1966, page 465, FIG. 1), the fundamental operability of the system of the present invention has been confirmed.

What is claimed is:

1. A process for burning a solid fuel selected from the group consisting of coal, lignite, wood and garbage consisting essentially of

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- a. burning said fuel in a dual pulse-jet engine system in which the two combustion zones in said system are vertically disposed and aligned side by side; further in which combustion gases are discharged from said zones essentially from the top of each of said zones in an upward direction through a narrow, vertically elongated flow channel, in which at the upper end of each channel the flow channel extends in the direction of the flow channel of the adjacent combustion zone so that the exit openings of the channels are opposite one another whereby hot combustion gases containing entrained ash are propelled back and forth between said flow channels; further in which combustion air is cyclically drawn upward into each of said combustion zones centrally through the bottom of said zones;
 - b. maintaining the average temperature within said zones and channels at a temperature above the melting point of the ash produced by burning said fuel;
 - c. capturing entrained ash particles in said combustion gas as a molten slag on the interior surfaces of the boundaries of said combustion zones and flow channels;
 - d. draining said slag downwardly along said surfaces to the bottom of said combustion zones; and
 - e. removing said slag from the peripheral area of the bottom of said zones.
2. The process of claim 1 in which a gas turbine power generation zone is disposed adjacent said exit openings, and wherein said hot combustion gases are employed as the motive fluid in said power generation zone to thereby generate power.
 3. The process of claim 1 in which a fluid is passed adjacent said exit openings, and wherein said hot combustion gases are employed to heat said fluid.
 4. The process of claim 2 in which said fuel is coal.
 5. The process of claim 3 in which said fuel is coal.

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