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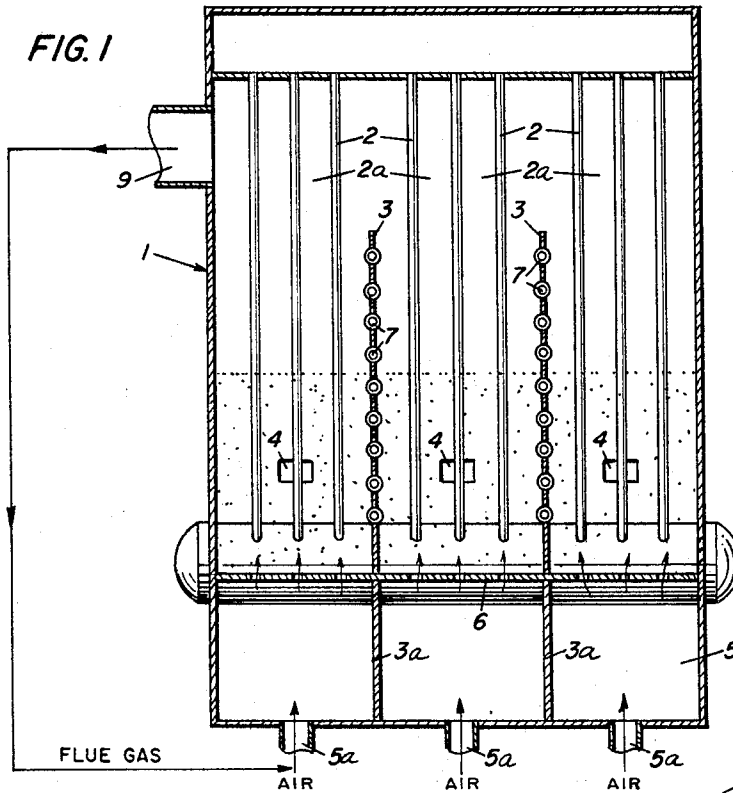
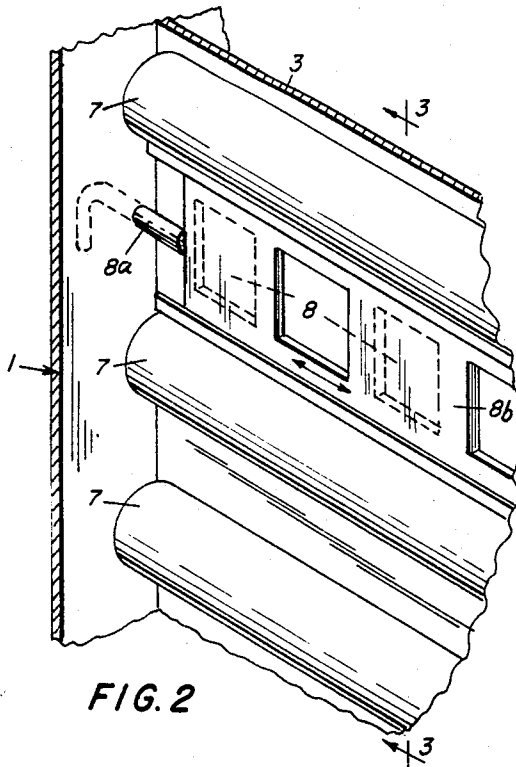
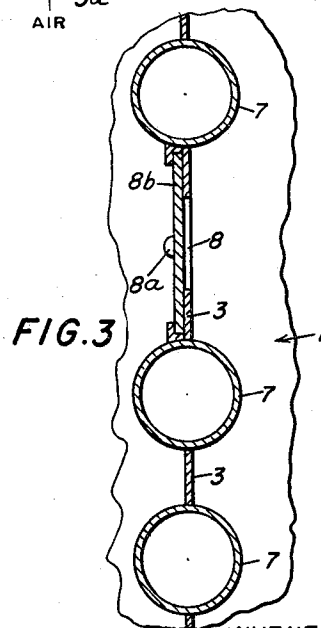
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SYSTEM FOR REGULATING THE TOTAL HEAT OUTPUT IN A BURNING
FLUIDIZED BED HEAT EXCHANGER OR BOILER

Filed March 16, 1967

2 Sheets-Sheet 1



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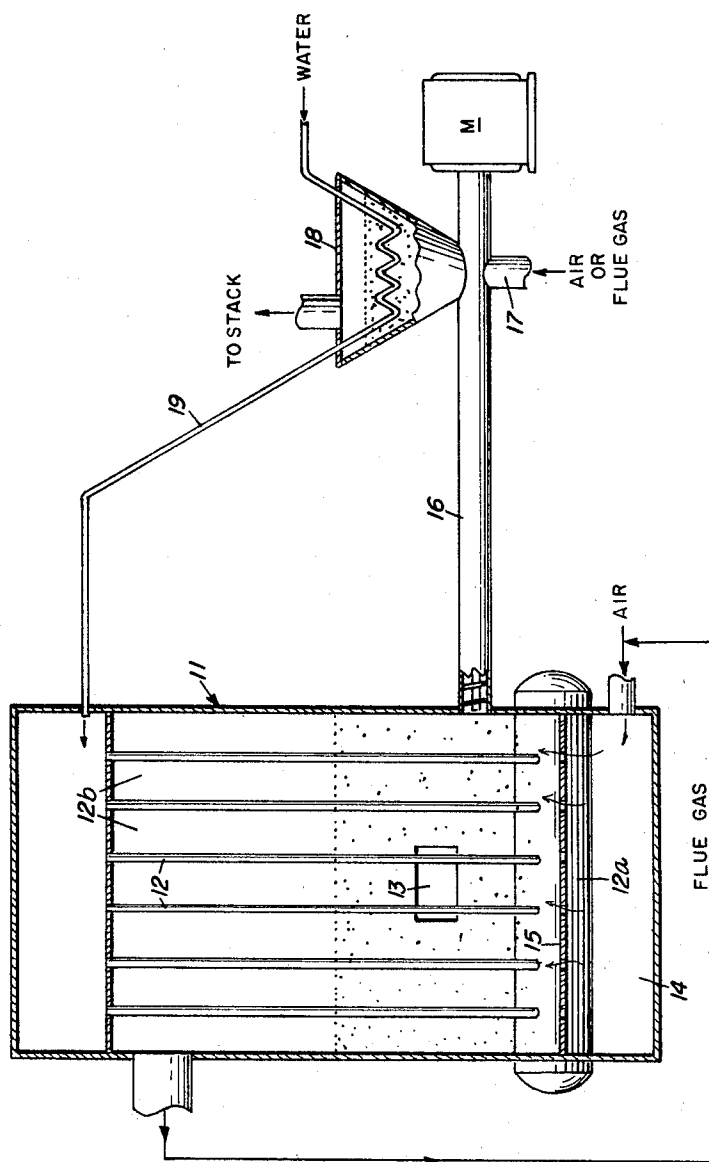


FIG. 4

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SYSTEM FOR REGULATING THE TOTAL HEAT OUTPUT IN A BURNING FLUIDIZED BED HEAT EXCHANGER OR BOILER

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ABSTRACT OF THE DISCLOSURE

The degree of direct contact between a fluidized burning bed of coal and the immersed tubes of a boiler is varied by changing the height of the bed by means of a bed transfer screw connected to the boiler and an adjacent bed holding vessel. Alternatively, the boiler can be partitioned into a plurality of beds, and the degree of contact between beds and tubes is then varied by shutting down or starting up one or more beds.

The invention relates to a system employing a fluidized bed of burning coal or other solid carbonaceous fuels such as lignite or petroleum coke as the heating medium in heat exchangers and boilers.

A recent development in the field of coal utilization has shown that a burning bed of fluidized coal surrounding a plurality of heat exchange conduits such as boiler tubes results in a substantially higher rate of heat transfer to the fluid material in the conduits than had previously been attained with coal fuels in conventional boilers and the like. However, difficulties have been encountered when trying to control the total bed heat output (e.g., the pounds of steam per hour produced by the boiler). Specifically, conventional combustion air and fuel regulation techniques can be employed to control total heat output only within very narrow heat output ranges because (1) the amount of air being supplied can be varied only within certain specified limits between a low value wherein fluidization of the bed cannot be maintained, and an upper limit wherein the fluid bed particles will be lifted out of the bed into the gas stream resulting in a loss of bed material, and (2) bed temperature cannot be lowered beyond a minimum temperature below which coal will fail to ignite, and above a high temperature limit wherein the ash material in the bed formed from coal combustion will tend to fuse or soften, become sticky, and tend to agglomerate to other particles, which agglomeration will result in collapse of the fluidized bed, spouting, slugging, channeling, and loss of the combustion reaction.

We have now developed a system for controlling the heat transfer from such beds over a wide range of total heat output. Generally, the invention comprises a process and apparatus for varying the amount of heat exchange surface in direct contact with the bed or, in other words, varying the degree of indirect heat exchange contact between the bed and the fluid material being heated.

It is therefore an object of the present invention to effect a wide range of total heat output from a burning fluidized bed of coal or other solid carbonaceous fuel.

A further object is to provide a system for deactivating portions of the burning bed, which deactivated beds can be easily re-ignited and again brought in direct contact with the heat exchange conduits.

Another object is to provide a system for controlling the height of the burning fluidized bed of coal in contact with the heat exchange conduits.

Other objects and advantages will be obvious from the detailed description of the system appearing in the follow-

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ing portion of the specification taken in conjunction with the drawings in which

FIG. 1 is a sectional view of one embodiment of the system; and

FIG. 2 is a fragmentary perspective view of a modification of one of the elements of FIG. 1;

FIG. 3 is a sectional view along the line 3—3 of FIG. 2; and

FIG. 4 is a sectional view of an alternative embodiment of the system.

Referring to FIG. 1, one system is shown for controlling direct contact between the burning, fluidized fuel and the heat exchange conduits wherein numeral 1 designates a boiler with a plurality of parallel tubes 2 through which water (or some other fluid material) is to be passed and heated. Wall partitions 3 divide the space 2a (which surrounds the tubes 2) into a plurality of compartments or vessels, each compartment having a fuel port 4. By this arrangement the water passes in parallel through the compartments. Below the space 2a is a plenum 5 divided into a plurality of sections by partitions 3a. Each plenum section is immediately below one of the compartments in the space 2a.

During operation of the boiler, solid carbonaceous fuel such as coal is continuously injected into each compartment by ports 4. The coal is initially heated to its self-ignition temperature by a hot, fluidized bed of particulate material contained in each compartment such as coal ash, other inert materials including crushed rock and refractory grog, or, in some instances, an oxidizing catalyst. Prior to coal injection, externally supplied hot gases derived, for example, by the burning of supplemental fuels are employed to heat the ash or other particulate material in the compartments to desired temperatures. Combustion and fluidizing air for the coal is passed to the space 2a in each compartment by fans (not shown) via a plenum opening 5a and an air distribution grid 6. As a result, a burning, fluidized bed of coal surrounds the tubes 2 in each compartment, through which tubes water or other fluid material passes in indirect contact heat exchange with the burning fuel.

In the case of a low ash solid fuel such as petroleum coke, fuel ignition and process temperature control do not require the presence of a hot, fluidized bed of inert or catalytic material in the compartments. Therefore, such fuels can be initially heated to self-ignition with externally supplied hot gases.

If a reduction is necessitated in the total heat output of an established burning bed, and the air and coal addition rates have already been adjusted to their minimum points whereby a further reduction in flow rates would prevent bed fluidization or lower the bed temperature to a point which would not support spontaneous combustion of incoming coal, one or more (but not all) of the compartments is deactivated by stopping coal feed therein and allowing the bed temperature of the deactivated sections to cool to a temperature approximating the temperature of water, steam or the other fluid material being heated in the tubes 2. The remaining active beds are maintained at proper conditions of fluidizing air and coal feed, thus precluding loss of bed ignition in these active compartments, while the inactive beds can be left in a fluidized condition or allowed to become static by stopping the flow of fluidizing air through the appropriate plenum section or sections. These inactive beds can also be cooled by providing cooling water through the tubes 7 contained in the partitions 3 adjacent each inactive bed.

Later, if an increase in the total heat output is necessitated, and the air and coal addition rates in the active beds have already been adjusted to their maximum points whereby a further increase in flow rates would lift parti-

cles out of these beds or increase bed temperature to a point where ash fusion occurs, one or more of the inactive beds is reactivated by (1) re-establishing fluidizing and combustion air (if it has previously been secured), and (2) stopping the flow of cooling water through tube 7 in the boundary partition or partitions 3 so that these partitions can be heated up by adjacent active beds to a point which will ignite a combustible fuel which is fed into the inactive bed (or beds). Ignition of the combustibles which can either be the basic coal fuel or an intermediate lower temperature igniting material such as charcoal, oil or gas, then proceeds to bring the entire bed up to active coal oxidizing condition, and the operation is re-established with further control by means of coal feed and fluidizing air addition.

Referring to FIGS. 2 and 3, another manner of providing for re-activation of an inactive bed in a compartment is by means of a series of ports 8 in each of the compartment partitions 3. That is, each series of ports 8 between an active and inactive bed can be opened by a rod 8a and sliding valve 8b, which rod is mechanically or electrically actuated in a conventional manner, to permit the injection of active bed particles into the inactive bed. This causes combustible, active bed particles fed into the inactive compartment to ignite in the air therein and thereby re-establish oxidation and operating temperatures in the inactive compartment. This system obviously requires that there always be at least one active bed adjacent an inactive bed.

A still further manner for reactivating an inactive compartment involves recirculating hot flue gases, which exit from the boiler through conduit 9, back to the plenum section below the inactive compartment. These hot gases then raise the bed temperature to the self-ignition point of the basic coal fuel, at which time combustion air and coal feed are injected and the operation re-established.

Referring to FIG. 4, another system for controlling contact between the burning fluidized bed and the heat exchange conduits is shown wherein numeral 11 designates a boiler vessel with a plurality of tubes 12 extending from a header 12a in the bottom to the top of the vessel. Coal or other solid carbonaceous fuel is fed to the space 12b surrounding the tubes by a fuel port 13. Fluidizing and combustion air is pumped by a fan (not shown) into the plenum 14, through distribution grid 15 and into the space 12b. To decrease the total heat output of the active bed in space 12b, a portion of the bed material is removed from the boiler by means of a reversible, motor driven transfer screw 16. This action reduces the height of the active bed whereby less contact between the boiler tubes and bed is effected. Pneumatic transfer or a drag chain can also be employed as the transfer device. Air from a suitable source or recirculated flue gases from the boiler, injected through port 17 on the screw, pneumatically removes the bed material from the screw and places it as a fluidized suspension within holding vessel or container 18. Remaining combustible material in the suspension is oxidized by the addition of air through port 17. Boiler water or another coolant passing through the conduit 19 in the holding vessel 18 can be employed to cool the resultant inert suspension. Alternatively, cooling can be accomplished by the addition of excess air. For an extended period of reduced load on the boiler, the bed in holding vessel 18 can be allowed to go static, but it must be refluidized before additional quantities of active bed material are added to it via screw 16. Restoration of the boiler output is accomplished by reversing the screw drive 16a, and delivering the inactive bed material from holding vessel 18 back into the active bed in space 12b in the boiler. New coal from port 13 in conjunction with the hot active bed restores the re-injected bed material to its former temperature condition. As the active bed material rises, more of the outer surface of the boiler tubes 12 comes in direct contact with the active bed material and the overall heat output of the boiler is increased.

By the system of the present invention, a high capacity coal fuel heat exchanger has been devised, constructed and operated wherein the total heat output of the unit can be readily controlled.

While the particular system herein described is well adapted to carry out the objects of the present invention, it is to be understood that various modifications and changes may be made all coming within the scope of the following claims.

What is claimed is:

1. A process for heating a fluid material employing a solid particulate carbonaceous material as the fuel comprising:

- (a) passing said fluid material through an indirect contact heat exchange with a plurality of adjacent burning, fluidized beds of said fuel, the resultant heated fuel material exiting from said plurality of beds into a single collection zone;
- (b) decreasing the total heat output of said fuel to said fluid material by deactivating combustion of said fuel in at least one of said plurality of beds while maintaining at least one of said plurality of beds in an active, burning, fluidized state;
- (c) maintaining at least one active burning fluidized bed adjacent each deactivated bed;
- (d) and subsequently increasing the total heat output of said fuel to said fluid material by re-establishing a burning, fluidized bed of said fuel in at least one of said deactivated beds, which re-establishing step comprises injecting bed material from an active bed into an adjacent deactivated bed, and then injecting more fuel into said adjacent deactivated bed.

2. The process of claim 1 further comprising cooling each deactivated bed immediately after deactivation by passing a cooling medium in indirect contact heat exchange with each deactivated bed, and stopping the flow of said cooling medium to a deactivated bed when re-establishing combustion in said bed.

3. A process for heating a fluid material employing a solid particulate carbonaceous material as the fuel comprising:

- (a) passing said fluid material through and in indirect contact heat exchange with a burning, fluidized bed of said fuel, the degree of said indirect contact being directly proportional to the height of said bed;
- (b) regulating the total heat output of said fuel to said fluid material by varying the height of said bed while continuously maintaining said bed in a burning, fluidized state, said step of varying the height of said bed comprising transferring bed material between said bed and a bed material holding zone.

4. A process for heating a fluid material employing particulate coal as the fuel comprising:

- (a) passing said fluid material through and in indirect contact heat exchange with a burning, fluidized bed of said fuel, the degree of said indirect contact being directly proportional to the height of said bed;
- (b) regulating the total heat output of said fuel to said fluid material by varying the height of said bed while continuously maintaining said bed in a burning, fluidized state.

5. An apparatus for heating a fluid material employing a solid particulate carbonaceous material as the fuel comprising:

- (a) a plurality of adjacent vessels;
- (b) means to fluidize and burn said fuel in said vessels;
- (c) a common partition wall between each pair of adjacent vessels, each of said walls having port means to allow transfer of fluidized bed material between adjacent vessels, means external to said vessels to open and close said port means;
- (d) conduit means extending through said vessels;
- (e) means to pass said fluid material through said conduit means; and

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(f) a chamber connected to said conduit means to receive heated fluid material exiting from said vessels.

6. The apparatus of claim 5 wherein said conduit means comprises a plurality of conduits to pass said fluid material in parallel through said plurality of vessels; and wherein said collection chamber is directly connected to the fluid material conduits in each of said vessels. 5

7. The apparatus of claim 6 wherein each of said partition walls includes conduit means contained therein to convey a cooling medium therethrough and thereby cool each wall. 10

8. An apparatus for heating a fluid material employing a solid, particulate carbonaceous material as the fuel comprising:

- (a) a vessel; 15
- (b) means to fluidized and burn said fuel in said vessel;
- (c) a container adjacent said vessel;
- (d) means connected to said vessel and said container to transfer bed material between said vessel and said container; 20
- (e) pneumatic means to transfer bed material between said transfer means and said container;

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(f) means to fluidize particulate material in said container;

(g) conduit means extending through said vessel from the bottom portion of said vessel to the top portion; and

(h) means to pass said fluid material through said conduit means.

9. The apparatus of claim 8 wherein said means to transfer bed material between said vessel and said container comprises a reversible screw conveyor.

10. The apparatus of claim 9 further including conduit means extending through said container; and means to pass a cooling medium through said latter conduit means.

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