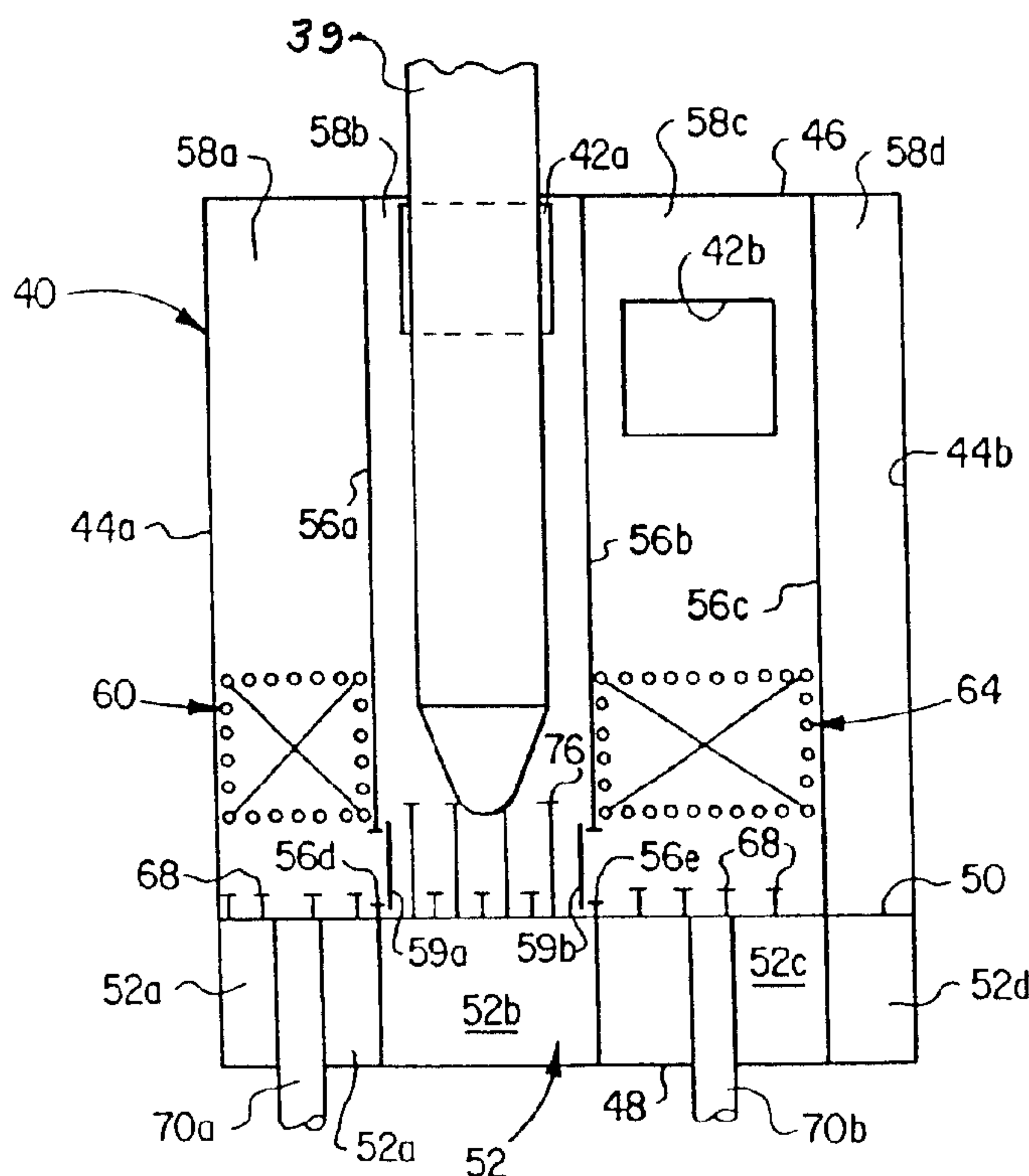




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 RECYCLE HEAT EXCHANGER



(57) Abrégé/Abstract:

A fluidized bed combustion system and method in which a recycle heat exchanger is located adjacent the furnace section of the recycle heat exchanger. Heat exchange surfaces are provided in one compartment of the heat exchanger for removing heat from the solids, and a bypass compartment is provided through which the solids directly pass to the furnace during start-up and low load conditions. A separate cooling compartment for the separated solids is disposed in the recycle heat exchange and valves are provided to selectively control the flow of solids between compartments.

FLUIDIZED BED COMBUSTION SYSTEM AND METHOD HAVING
A MULTICOMPARTMENT EXTERNAL RECYCLE HEAT EXCHANGER

Abstract of the Disclosure

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compartment is provided through which the solids directly
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FLUIDIZED BED COMBUSTION SYSTEM AND METHOD HAVING
A MULTICOMPARTMENT EXTERNAL RECYCLE HEAT EXCHANGER

Background of the Invention

This invention relates to a fluidized bed combustion
5 system and a method of operating same and, more
particularly, to such a system and method in which a
multicompartment recycle heat exchanger is provided
adjacent the furnace section of the system.

Fluidized bed combustion systems are well known and
10 include a furnace section in which air is passed through a
bed of particulate material, including a fossil fuel, such
as coal, and a sorbent for the oxides of sulfur generated
as a result of combustion of the coal, to fluidize the bed
and to promote the combustion of the fuel at a relatively
15 low temperature. These types of combustion systems are
often used in steam generators in which water is passed in
a heat exchange relationship to the fluidized bed to

generate steam and permit high combustion efficiency and fuel flexibility, high sulfur adsorption and low nitrogen oxides emissions.

The most typical fluidized bed utilized in the furnace section of these type systems is commonly referred to as a "bubbling" fluidized bed in which the bed of particulate material has a relatively high density and a well-defined, or discrete, upper surface. Other types of systems utilize a "circulating" fluidized bed in which the fluidized bed density is below that of a typical bubbling fluidized bed, the fluidizing air velocity is equal to or greater than that of a bubbling bed, and the flue gases passing through the bed entrain a substantial amount of the fine particulate solids to the extent that they are substantially saturated therewith.

Circulating fluidized beds are characterized by relatively high internal and external solids recycling which makes them insensitive to fuel heat release patterns, thus minimizing temperature variations and, therefore, stabilizing the sulfur emissions at a low level. The high external solids recycling is achieved by disposing a cyclone separator at the furnace section outlet to receive the flue gases and the solids entrained thereby from the fluidized bed. The solids are separated

from the flue gases in the separator and the flue gases are passed to a heat recovery area while the solids are recycled back to the furnace through a seal pot or seal valve. This recycling improves the efficiency of the separator, and the resulting increase in the efficient use of sulfur adsorbent and fuel residence times reduces the adsorbent and fuel consumption.

In the operation of these types of fluidized beds, and, more particularly, those of the circulating type, there are several important considerations. For example, the flue gases and entrained solids must be maintained in the furnace section at a substantially isothermal temperature (usually approximately 1600°F) consistent with proper sulfur capture by the adsorbent. As a result, the maximum heat capacity (heat) of the flue gases passed to the heat recovery area and the maximum heat capacity of the separated solids recycled through the cyclone and to the furnace section are limited by this temperature. In a cycle requiring only superheat duty and no reheat duty, the heat content of the flue gases at the furnace section outlet is usually sufficient to provide the necessary heat for use in the heat recovery area of the steam generator downstream of the separator. Therefore, the heat content of the recycled solids is not needed.

However, in a steam generator using a circulating fluidized bed with sulfur capture and a cycle that requires reheat duty as well as superheater duty, the existing heat available in the flue gases at the furnace section outlet is not sufficient. At the same time, heat in the furnace cyclone recycle loop is in excess of the steam generator duty requirements. For such a cycle, the design must be such that the heat in the recycled solids must be utilized before the solids are reintroduced to the furnace section.

To provide this extra heat capacity, a recycle heat exchanger is sometimes located between the separator solids outlet and the fluidized bed of the furnace section. The recycle heat exchanger includes superheater heat exchange surface and receives the separated solids from the separator and functions to transfer heat from the solids to the superheater surfaces at relatively high heat transfer rates before the solids are reintroduced to the furnace section. The heat from the superheater surfaces is then transferred to cooling circuits in the heat recovery area to supply the necessary reheat duty.

The simplest technique for controlling the amount of heat transfer in the recycle heat exchanger is to vary the level of solids therein. However, situations exist in

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which a sufficient degree of freedom in choosing the recycle bed height is not available, such as for example, when a minimum fluidized bed solids depth or pressure is required for reasons unrelated to heat transfer. In this case, the heat transfer may
5 be controlled by utilizing "plug valves" or "L valves" for diverting a portion of the recycled solids so that they do not contact and become cooled by the recycle heat exchanger. The solids from the diverting path and from the heat exchanger path are recombined or each stream is directly routed to the furnace
10 section to complete the recycle path. In this manner, the proper transfer of heat to the heat exchanger surface is achieved for the unit load existing. However, these type arrangements require the use of moving parts within the solids system and/or need external solids flow conduits with associated
15 aeration equipment which adds considerable cost to the system.

In order to reduce these costs, a system has been devised wherein a recycle heat exchanger is provided for receiving the separated solids and
distributing them back to the fluidized bed in
20 the furnace section. The recycle heat exchanger is

located externally of the furnace section of the system and includes an inlet chamber for receiving the solids discharged from the separators. Two additional chambers are provided which receive the solids from the inlet chamber. The solids are fluidized in the additional chambers and heat exchange surfaces are provided in one of the additional chambers for extracting heat from the solids. The solids in the additional chamber are permitted to flow into an outlet chamber when the level in the former chamber exceeds a predetermined height set by the height of an overflow weir. The solids entering the outlet chamber are then discharged back to the fluidized bed in the furnace section.

However, there are some disadvantages associated with this type of operation. For example, the space available for heat exchanger surfaces is limited, and pressure fluctuations in the furnace section are transmitted to the external heat exchanger which results in erratic performance. Also, the solids are directed from the heat exchanger through one discharge pipe to one relatively small area of the furnace section which is inconsistent with uniform mixing and distribution of the solids. Also, there is no provision for directly controlling the flow of solids between compartments. Further, this system relies

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on pressure differential to drive the solids from the heat exchanger to the furnace section which requires power. Still further, there is no provision for controlling the solids inventory, or furnace loading.

5 Summary of the Invention

 Accordingly the present invention seeks to provide a fluidized bed combustion system and method which utilizes a recycle heat exchanger disposed adjacent the furnace section of the combustion system for removing heat from the separated
10 solids before they are recycled back to the furnace.

 Further still the present invention seeks to provide a system and method of the above type in which heat is removed from the separated solids without reducing the temperature of the flue gases.

15 Further the present invention seeks to provide a system and method of the above type in which the recycle heat exchanger includes a direct bypass for routing the separated solids directly and uniformly to the furnace section without passing over any heat exchange surfaces, during start-up, shut-down,
20 unit trip and low load conditions.

 Yet further the present invention seeks to provide a system and method of the above type in which multiple compartments are provided in the recycle heat exchanger and the flow of separated solids between compartments is selectively controlled to
25 increase the heat exchange efficiency.

 Still further the present invention seeks to provide a system and method of the above type in which the recycle heat exchanger is isolated from pressure fluctuations in the furnace.

 Another aspect of the present invention seeks to provide a
30 system and method of the above type in which the separated solids are driven from the recycle heat exchanger to the furnace

by height differentials.

The invention in one broad aspect provides a fluidized bed combustion system, comprising an enclosure, means defining a furnace section in the enclosure, means for forming a fluidized
5 bed in the furnace section, separating means external of the enclosure for receiving a mixture of flue gases and entrained particulate material from the fluidized bed in the furnace section and separating the entrained particulate material from the flue gases. A heat recovery section external of the
10 enclosure and is connected to the separating means for receiving the separated flue gases. A recycle heat exchanger is disposed externally of the enclosure and the furnace section and comprises means defining a first compartment and a second compartment separated by a common wall. Means connect the
15 separating means to the first compartment to transfer the separated particulate material to the first compartment and an opening extends through the common wall for permitting the separated particulate material to flow from the first compartment to the second compartment. Control means is
20 associated with the opening and movable between an open position in which it permits the flow of the separated material from the first compartment to the second compartment and a closed position in which it prevents the flow. Heat exchange means is disposed in the second compartment for removing heat from the
25 separated particulate material in the second compartment. First and second passage means respectively connect the first and second compartments to the furnace section so that, in the open position of the control means, the separated particulate material flows from the first compartment to the second
30 compartment and through the second passage means to the furnace section and in the closed position of the control means, the

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separated particulate material flows from the first compartment through the first passage means to the furnace section.

Another aspect of the invention pertains to a method for operating a fluidized bed combustion system including a furnace enclosure in fluid communication with a heat recovery area and having first and second compartments separated by a common wall having an opening therein, comprising forming in the furnace enclosure a combustible fluidized bed of particulate material, combusting the material in the furnace enclosure to produce heat and flue gases, the flue gases entraining a portion of the particulate material, separating the entrained particulate material from the flue gases, passing the separated flue gases to the heat recovery area, passing the separated particulate material to the first compartment, controlling flow of the separated particulate material so that the material either passes directly from the first compartment to the furnace enclosure or passes from the first compartment through the opening in the common wall to the second compartment where heat can be removed and then to the furnace enclosure.

More particularly the system of the present invention includes a recycle heat exchanger located adjacent the furnace section of the system. The flue gases and entrained particulate materials from the fluidized bed in the furnace section are separated, the flue gases are passed to a heat recovery area and the separated solids are passed to the recycle heat exchanger. Heat exchange surfaces are provided in one compartment of the heat exchanger for removing heat from the solids and a bypass compartment is provided through which the solids directly pass to the furnace during start-up and low load conditions. A separate cooling compartment for the separated solids is disposed in the recycle heat exchange and means are provided to selectively control the flow of solids between compartments.

Additional Summary of the Invention

A fluidized bed combustion system, comprising an enclosure, with a means defining a furnace section in the enclosure, and a means for forming a fluidized bed in the furnace section, separating means external of the enclosure for receiving a mixture of flue gases and entrained particulate material from the fluidized bed in the furnace section and separating the entrained particulate material from the flue gases. A heat recovery section external of the enclosure and in connection with the separating means for receiving the separated flue gases. A recycle heat exchanger disposed externally of the enclosure and the furnace section and including means defining a first compartment and a second compartment, with a means for transferring the separated particulate material from the separating means to the first compartment, with a means connecting the compartments there between for allowing the separated particulate material in the first compartment to flow to the second compartment, means cooperating with the connecting means for controlling the flow of the separated particulate material between the compartments and operable in a first mode for permitting the flow to the second compartment and in a second mode for preventing the flow to the second compartment. First and second passage means respectively connecting the first and second compartments to the furnace section so that, in the first mode of the controlling means, the separated particulate material flows from the first compartment to the second compartment and through the second passage means to the furnace section and, in the second mode of the controlling means, the separated particulate material flows from the first compartment through the first passage means to the furnace section.

A method for operating a fluidized bed combustion system comprising the steps of providing a fluidized bed combustion system having an enclosure in fluid communication with a heat recovery area and at least first and second compartments forming in the enclosure a combustible fluidized bed of particulate material. Combusting the fluidized bed to produce heat and flue gases, the flue gases entraining a portion of the particulate material, separating the entrained particulate material from the flue gases, passing the separated flue gases to the heat recovery area, passing the separated particulate material to the first compartment, controlling the passage of the separated particulate material out of the first compartment by controlling valve means between first and second positions, such that, in the first position the separated particulate material flows to the fluidized bed in the enclosure directly and in the second position the separated particulate material flows to the second compartment and from the second compartment to the fluidized bed in the enclosure.

Brief Description of the Drawings

The above brief description, as well as further objects, features and advantages of the present invention will be more fully appreciated by reference to the following detailed description of the presently preferred but nonetheless illustrative embodiments in accordance with the present invention when taken in conjunction with the accompanying drawing wherein:

Fig. 1 is a schematic representation depicting the system of the present invention;

Fig. 2 is a cross-sectional view taken along the line 2-2 of Fig. 1;

Fig. 3 is a cross-sectional view taken along the line 3-3 of Fig. 2; and

Fig. 4 is a partial, enlarged perspective view of a portion of a wall of the enclosure of the system of Fig. 1; as shown with Fig. 1.

Description of the Preferred Embodiment

The drawings depict the fluidized bed combustion system of the present invention used for the generation of steam and including an upright water-cooled enclosure, referred to in general by the reference numeral 10, having a front wall 12a, a rear wall 12b and two sidewalls one of which is shown by the reference numeral 14. The upper portion of the enclosure 10 is closed by a roof 16 and the lower portion includes a floor 18.

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5 A plurality of air distributor nozzles 20 are mounted in corresponding openings formed in a plate 22 extending across the lower portion of the enclosure 10. The plate 22 is spaced from the floor 18 to define an air plenum 24 which is adapted to receive air from an external source (not shown) and selectively distribute the air through the plate 22 and to portions of the enclosure 10, as will be described.

10 A coal feeder system, shown in general by the reference numeral 25, is provided adjacent the front wall 12 for introducing particulate material containing fuel into the enclosure 10. Since the feeder system 25 is conventional it will not be described in any further detail. It is understood that a particulate sorbent
15 material can also be introduced into the enclosure 10 for absorbing the sulfur generated as a result of the combustion of the fuel. This sorbent material may be introduced through the feeder 25 or independently through openings in the walls 12a, 12b, or 14.

20 The particulate fuel and sorbent material (hereinafter termed "solids") in the enclosure 10 is fluidized by the air from the plenum 24 as the air passes upwardly through the plate 22. This air promotes the combustion of the fuel in the solids and the resulting

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mixture of combustion gases and the air (hereinafter termed "flue gases") rises in the enclosure by forced convection and entrains a portion of the solids to form a column of decreasing solids density in the upright enclosure 10 to a given elevation, above which the density remains substantially constant.

A cyclone separator 26 extends adjacent the enclosure 10 and is connected thereto via a duct 28 extending from an outlet provided in the rear wall 12b of the enclosure 10 to an inlet provided through the separator wall. The separator 26 includes a hopper portion 26a extending downwardly therefrom. Although reference is made to one separator 26, it is understood that one or more additional separators (not shown) may be disposed behind the separator 26. The number and size of separators used is determined by the capacity of the steam generator and economic considerations.

The separator 26 receives the flue gases and the entrained particle material from the enclosure 10 in a manner to be described and operates in a conventional manner to disengage the solids from the flue gases due to the centrifugal forces created in the separator. The separated flue gases, which are substantially free of solids, pass, via a duct 30 located immediately above the

separator 26, into a heat recovery section shown in general by the reference numeral 32.

5 The heat recovery section 32 includes an enclosure 34 divided by a vertical partition 35 into a first passage which houses a reheater 36, and a second passage which houses a primary superheater 37 and an economizer 38, all of which are formed by a plurality of heat exchange tubes extending in the path of the gases from the separator 26 as they pass through the enclosure 34. An opening 35a is provided in the upper portion of the partition 35 to permit a portion of the gases to flow into the passage containing the superheater 37 and the economizer 38. After passing across the reheater 36, superheater 37 and the economizer 38 in the two parallel passes, the gases exit the enclosure 34 through an outlet 34a formed in the rear wall thereof.

10 The separated solids in the separator 26 pass downwardly, by gravity, into and through the hopper portion 26a from which they pass, via a dipleg 39, into a recycle heat exchanger enclosure, shown in general by the reference numeral 40, provided adjacent the enclosure 10 and below the separator 26. As better shown in Figs. 2 and 3, the enclosure 40 includes a front wall 42 a rear wall 43 and two sidewalls 44a and 44b. A roof 46 and a

floor 48 extend across the upper ends and the lower ends, respectively, of the walls 42, 43, 44a and 44b. A plate 50 extends across the enclosure 40 in a slightly-spaced relation to the floor 48 to define a plenum 52. Three
5 vertical partitions 56a, 56b and 56c extend in a spaced, parallel relation to, and between, the sidewalls 44a and 44b to define four compartments 58a, 58b 58c and 58d. The partitions 56a, 56b and 56c also extend into the plenum 52 to divide it into three sections 52a, 52b and 52c
10 (Fig.3). It is understood that dampers, or the like, (not shown) can be provided to selectively distribute air to the individual plenum sections 52a, 52b and 52c.

Two openings 56d and 56e are provided in the lower portions of the partition 56a and 56b, respectively, just
15 above the plate 50, and a pair of sliding gate valves 59a and 59b are mounted relative to the partitions 56a and 56b, to control the flow of solids through the openings 56c and 56d as will be discussed.

A bank of heat exchange tubes, shown in general by
20 the reference numeral 60, are provided in the compartment 58a with the respective end portions of each tube extending outwardly through appropriate openings through in the rear wall 43. The ends of each tube are connected to an inlet header 62a and outlet header 62b, respectively

(Fig. 2). Similarly, a bank of heat exchange tubes 64 are provided in the compartment 58c and are connected at their respective ends to an inlet header 66a and an outer header 66b.

5 As better shown in Fig. 3, a plurality of air discharge nozzles 68 extend upwardly from the plate 50 in each of the compartments 58a, 58b and 58c and are mounted in corresponding openings formed through the plate for receiving air from the plenum sections 52a, 52b and 52c
10 and introducing the air into the compartments 58a, 58b and 58c, respectively.

 A pair of drain pipes 70a and 70b are provided in the plenum sections 52a and 52b, respectively, and extend downwardly from the plate 50 and through the floor 48 to
15 discharge solids from the latter compartments.

 As opening 42a (Fig. 3) is provided through upper portion of the front wall 42 of the enclosure 40 which registers with the compartment 58b, and an opening 42b is provided through the upper portion of the wall 42 in
20 registry with the compartment 58c. The opening 42a is located an elevation higher than the opening 42b for reasons to be described. Two conduits 72a and 72b respectively connect the openings 42a and 42b to corresponding openings formed in the rear wall 12b of the

enclosure 10 to permit solids from the compartments 58a and 58c to be transferred to the enclosure 10 as will be described.

5 The front wall 12a, the rear wall 12b, the sidewalls 14, roof 16, as well as the walls defining the separator 26 and the heat recovery enclosure 34 all are formed of membrane-type walls an example of which is depicted in Fig. 4. As shown, each wall is formed by a plurality of finned tubes 74 disposed in a vertically extending, air
10 tight relationship with adjacent finned tubes being connected along their lengths.

A steam drum 80 is located above the enclosure 10 and, although not shown in the drawings, it is understood that a plurality of headers are disposed at the ends of
15 the various walls described above. Also, a plurality of downcomers, pipes, risers, headers etc., some of which are shown by the reference numeral 80a, are utilized to establish a steam and water flow circuit including the steam drum 80, the tubes 74 forming the aforementioned
20 water tube walls and the tubes 60 and 64 in the compartments 58a and 58c. The economizer 38 receives feed-water and discharges it to the drum 80 and the water is passed, in a predetermined sequence through this flow circuitry to convert the water to steam and heat the steam

by the heat generated by combustion of the particulate fuel material in the enclosure 10.

In operation, the solids are introduced into the enclosure 10 through the feeder system 25. Air from an external source is introduced at a sufficient pressure into the plenum 24 and the air passes through the nozzles 20 and into the enclosure 10 at a sufficient quantity and velocity to fluidize the solids in the latter section.

A lightoff burner (not shown), or the like, is provided to ignite the fuel material in the solids, and thereafter the fuel material is self-combusted by the heat in the furnace section. The flue gases pass upwardly through the enclosure 10 and entrain, or elutriate, a majority of the solids. The quantity of the air introduced, via the air plenum 24, through the nozzles 20 and into the interior of the enclosure 10 is established in accordance with the size of the solids so that a circulating fluidized bed is formed, i.e. the solids are fluidized to an extent that substantial entrainment or elutriation thereof is achieved. Thus the flue gases passing into the upper portion of the enclosure 10 are substantially saturated with the solids and the arrangement is such that the density of the bed is relatively high in the lower portion of the enclosure 10,

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decreases with height throughout the length of this enclosure 10 and is substantially constant and relatively low in the upper portion of the enclosure.

5 The saturated flue gases in the upper portion of the enclosure exit into the duct 28 and pass into the cyclone separator 26. In the separator 26, the solids are separated from the flue gases and the former passes from the separator through the dipleg 39 and into the enclosure 40. The clean flue gases from the separator 26 exit, via
10 the duct 30, and pass to the heat recovery section 32 for passage through the enclosure 34 and across the reheater 36, the superheater 37, and the economizer 38, before exiting through the outlet 34a to external equipment.

15 Normally, the sliding gate valve 59a is in its closed portion and the valve 59b is in its open position as shown in Fig. 2 so that the separated solids from the dipleg 39 enter the compartment 58b and pass, via the opening 56e, into the compartment 58c. Air is introduced into the
20 section 52c of the plenum 52 below the compartment 58c and is discharged through the corresponding nozzles 20 to fluidize the solids in the compartment 58c. The solids in the compartment 58c pass in a generally upwardly direction across the heat exchange tubes 64, exit via the opening

42b into the conduit 72b, and pass back into the enclosure 10. Although not normally necessary, the solids can be discharged from the compartment 58c, via the drain pipe 70b, as needed. During this operation, fluidizing air is not introduced into the air plenum section 52b associated with the compartment 58b and since the opening 42b in the wall 42a is at a greater height than the openings 42c, very little, if any, flow of solids through the compartment 58b occurs.

During initial start up and low load conditions, the sliding gate valve 59b is closed and the fluidizing air to the plenum section 52b is turned on while the air flow to the section 52c is turned off. The solids in the compartment 58c thus slump and therefore seal this volume from further flow. The solids from the dipleg 39 pass into the compartment 58b and the air passing into the compartment from the plenum section 52b and the nozzles 68 forces the material upwardly and outwardly through the opening 42a and the conduit 72a to the enclosure 10.

Since the compartment 58b does not contain heat exchanger tubes, it functions as a direct bypass, or a "seal pot", so that start up and low load operation can be achieved without exposing the heat exchanger tubes 64 to the hot recirculating solids.

Although normally all of the separated solids from the separator 26 are recycled, under certain circumstances it may be desirable to extract some solids from the system. In this case the sliding gate valve 59a is opened to expose the opening 56d in the partition 56a and air is introduced into the plenum section 52a. This induces solids flow from the compartment 58b, through the opening 56d, into the compartment 58a and across the heat exchange tubes 60 to cool the solids before they are discharged through the drain pipe 70a. During this operation any air flow through the plenum sections 52b and 52c is terminated and the sliding gate valve 59b closed, as needed.

The compartment 58d is provided for accommodating any additional heat exchange tubes to remove additional heat from the solids as might be needed.

Fluid, such as feedwater, is introduced to and circulated through the flow circuit described above in a predetermined sequence to convert the feedwater to steam and to reheat and superheat the steam. To this end, the heat removed from the solids by the heat exchanger tubes 60 and 64 in the compartments 58a and 58c can be used to provide reheat or additional superheat.

Another technique of selectively controlling the flow of solids through and between the compartments 58a, 58b and 58c is contemplated. According to this technique, the sliding gate valves 59a and 59b are eliminated and the
5 nozzles 68 in the compartment 58b are replaced by a plurality of nozzles 76 (Fig. 3) which extend above the height of the openings 56d and 56e. Thus, air introduced into the plenum section 52b would be discharged into the
10 compartment 52b at a height greater than the height of the openings 56d and 56e. As a result, the solids in the compartment 56b extending below the upper end of the nozzles 76 would not be fluidized but rather would tend to slump in the latter compartment, while the solids
15 extending above the nozzle 76 would be fluidized and thus flow upwardly through the compartment 58b and out the opening 42b in the wall 42 for passage, via the conduit 72a, to the enclosure 10. Thus very little, if any, solids flow from the compartment 58b through the openings
20 56d and 56e would occur. If air flow into the plenum section 58b, and therefore compartment 58b, is shut off, and air is passed into the plenum sections 52a or 52c, the latter air would induce the flow of solids from the compartment 58b to the compartments 58a or 58c as described above.

Thus, use of the nozzles 76 enables the solids flow between the compartments 58a, 58b and 58c to be selectively controlled. It is understood that the nozzle 76 can be used in place of the valves 59a and 59b or in addition thereto.

Several advantages result in the system of the present invention. For example, heat is removed from the separated solids exiting from the separator 26 before they are reintroduced to the enclosure 10, without reducing the temperature of the flue gases. Also, the separated gases are at a sufficient temperature to provide significant heating of the system fluid while the recycle heat exchanger can function to provide additional heating such as might be needed in a reheat cycle. Also the recycled solids can be passed directly from the dipleg 39 to the enclosure 10 during start-up or low load conditions prior to establishing adequate cooling steam flow to the tube 64 in the compartment 58c. Further, selective flow of the solids between the compartments 58a, 58b and 58c in the recycle heat exchanger enclosure 40 is permitted depending on the particular operating conditions.

It is understood that several variations may be made in the foregoing without departing from the scope of the present invention. For example, the heat removed from the

solids in the compartment 58c can be used for heating the system fluid in the furnace section or the economizer, etc. Also, other types of beds may be utilized in the enclosure 10 such as a circulating transport mode bed with constant density through its entire height or a bubbling bed, etc. Also a series heat recovery arrangement can be provided with superheat, reheat and/or economizer surface, or any combination thereof. Further, the number and/or location of the bypass channels in the recycle heat enclosure 40 can be varied.

Other modifications, changes and substitutions are intended in the foregoing disclosure and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A fluidized bed combustion system, comprising an enclosure, means defining a furnace section in said enclosure, means for forming a fluidized bed in said furnace section, separating means external of said enclosure for receiving a mixture of flue gases and entrained particulate material from said fluidized bed in said furnace section and separating the entrained particulate material from the flue gases, a heat recovery section external of said enclosure and connected to said separating means for receiving the separated flue gases, a recycle heat exchanger disposed externally of said enclosure and said furnace section and comprising means defining a first compartment and a second compartment separated by a common wall, means connecting said separating means to said first compartment to transfer the separated particulate material to the first compartment, an opening extending through said common wall for permitting the separated particulate material to flow from said first compartment to said second compartment, control means associated with said opening and movable between an open position in which it permits the flow of the separated material from said first compartment to said second compartment, and a closed position in which it prevents said flow, heat exchange means disposed in said second compartment for removing heat from the separated particulate material in said second compartment, and first and second passage means respectively connecting said first and second compartments to said furnace section so that, in said open position of said control means, said separated particulate material flows from said first compartment to said second compartment and through said second passage means to said furnace section, and, in said closed position of said control means, said separated particulate material flows from said first compartment through said first passage means to said furnace section.

2. The system of claim 1 wherein said recycle heat exchanger include a third compartment and further comprises means connecting said first compartment to said third compartment for allowing the separated particulate material in said first

compartment to flow to said third compartment, and control means for controlling the flow of the separated particulate material between said first compartment and said third compartment

3. The system of claim 2 wherein said latter control means is movable between an open position in which it permits the flow of the separated material from said first compartment to said third compartment, and a closed position in which it prevents said flow.

4. The system of claim 3 further comprising drain means associated with said third compartment for removing the separated particulate material from the third compartment.

5. The system of claim 2 further comprising heat exchange means disposed in said third compartment for removing heat from the separated particulate material in the third compartment.

6. The system of claim 1 or 2 further comprising means for selectively introducing air to each of said compartments to fluidize the separated particulate material therein and control said flow of the separated particulate material.

7. The system of claim 2 wherein said first compartment extends between said second compartment and said third compartment.

8. The system of claim 1 or 2 wherein said recycle heat exchanger further comprises a plurality of walls, at least a portion of said walls being formed by tubes, and

further comprises fluid flow circuit means for passing fluid through said tubes to transfer heat generated in said furnace section to the fluid.

9. The system of claim 8 wherein said flow circuit means further comprises means for passing the fluid through said second compartment of said recycle heat exchanger in heat exchange relation to the separated particulate material in said second compartment to transfer heat from the separated particulate material to the fluid to control the temperature of the separated particulate material passed from said second compartment section to said furnace section.

10. The system of claim 2 wherein said enclosure is comprised of walls, at least a portion of said walls being formed by tubes, and further comprising fluid flow circuit means for passing fluid through said tubes to transfer heat generated in said furnace section to the fluid, said flow circuit means comprising means for passing said fluid through said third compartment of said recycle heat exchanger in heat exchange relation to the separated particulate material in said third compartment to transfer heat from the separated particulate material to the fluid to cool the separated particulate material passed to said third compartment.

11. The system of claim 1 wherein said recycle heat exchanger is located between said separating means and said enclosure.

12. The system of claim 1 wherein the control means is a valve.

13. The system of claim 1 wherein said control means comprises means for introducing air into said first compartment at a level above that of said opening to cause

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the separated particulate material in said first compartment to flow directly, via said first passage means, to said furnace section.

14. The system of claim 13 wherein said control means further comprises means for selectively introducing air to said second compartment to cause the separated particulate material to flow from said first compartment to said second compartment.

15. A method for operating a fluidized bed combustion system including a furnace enclosure in fluid communication with a heat recovery area and having first and second compartments separated by a common wall having an opening therein, comprising:

forming in said furnace enclosure a combustible fluidized bed of particulate material;

combusting said material in said furnace enclosure to produce heat and flue gases, said flue gases entraining a portion of said particulate material;

separating said entrained particulate material from said flue gases;

passing said separated flue gases to said heat recovery area;

passing said separated particulate material to said first compartment, controlling flow of said separated particulate material so that said material either passes directly from said first compartment to said furnace enclosure or passes from said first compartment through said opening in the common wall to said second compartment where heat can be removed and then to said furnace enclosure.

16. The method of claim 15 wherein the step of controlling the flow of separate particulate material comprises selectively opening and closing a valve associated with the common wall.

17. The method of claim 15 wherein the step of

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controlling the flow of separated particulate material comprises selectively introducing air to the compartments to fluidize the separated particulate material therein and permit flow of the separated particulate material from said respective compartments to said furnace enclosure.

18. The method of claim 17 wherein the step of controlling the flow of separated particulate material further comprises selectively opening and closing a valve associated with the common wall.

19. The method of claim 15 wherein said system has a third compartment and wherein the step of controlling flow of separated particulate material includes selectively passing separated particulate material from said first compartment to said third compartment and further comprising the steps of removing heat from the separated particulate material in the third compartment and then draining the separated particulate material from said third compartment.

20. The method of claim 19 wherein said third compartment shares a common wall with said first compartment and wherein said step of controlling further comprises selectively opening and closing valves associated with the common walls.

21. The method of claim 19 wherein the step of controlling the flow of separated particulate material comprises selectively introducing air to each of the compartments to fluidize the separated particulate material therein and permit the flow of the separated particulate material between selective compartments and from said compartments.

22. The method of claim 21 wherein the third compartment shares a second common wall with the first compartment and wherein said step of controlling the flow of separated particulate material further comprises selectively opening and closing valves associated with the common walls.

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23. The method of claim 15 further comprising the step of passing fluid through water wall tubes forming walls of the compartment whereby heat within said separated particulate material is transferred to said fluid.

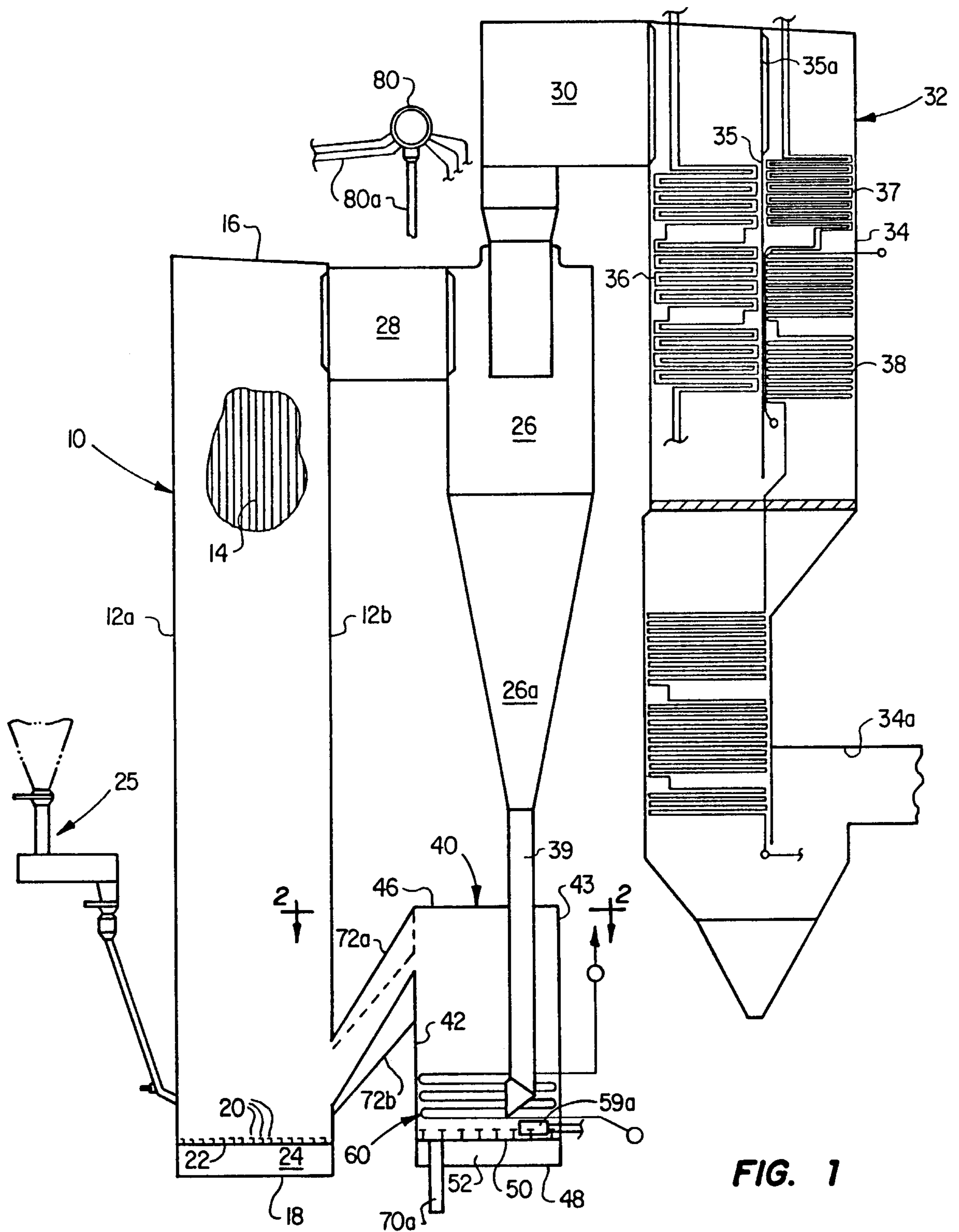


FIG. 1

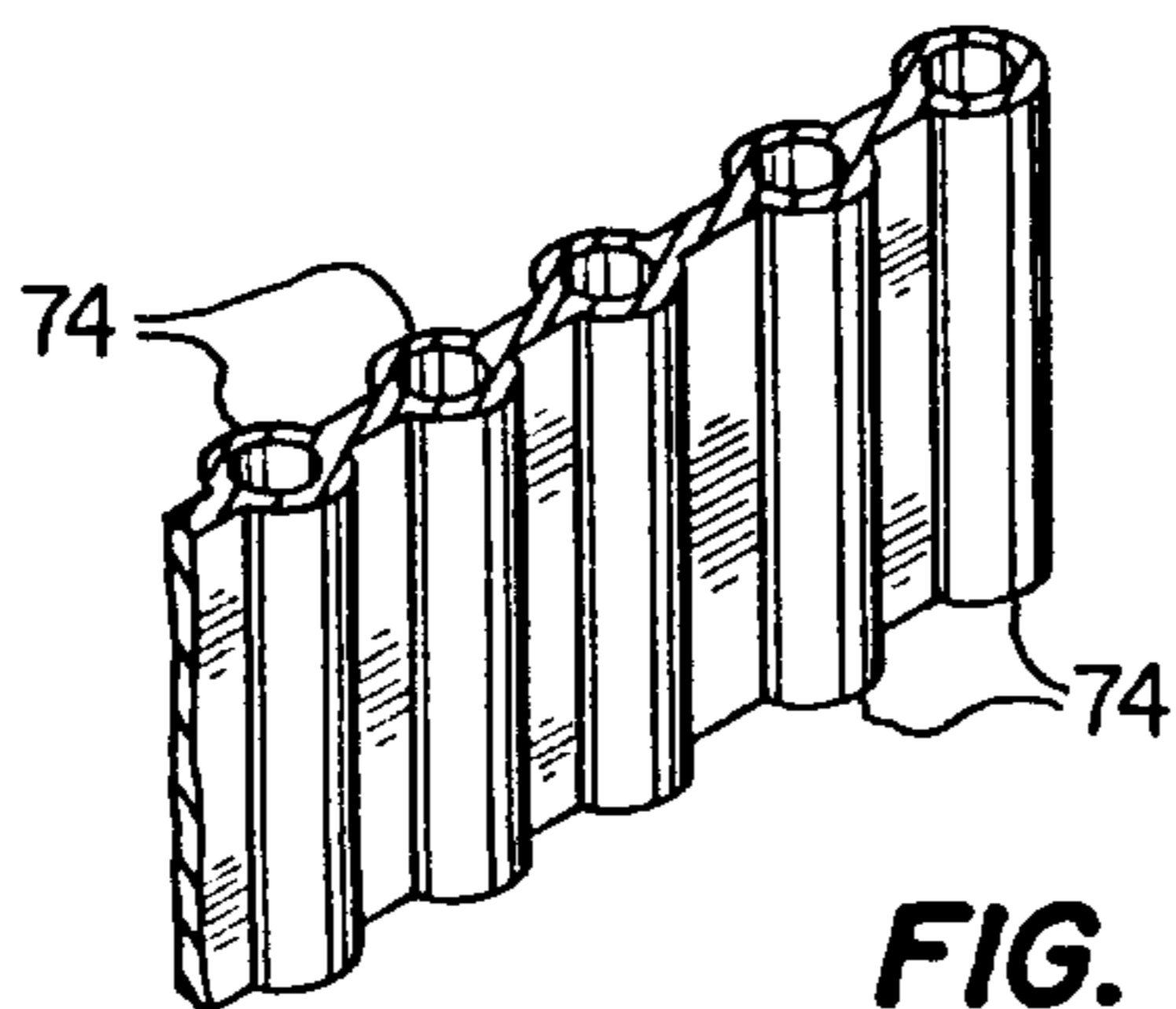


FIG. 4

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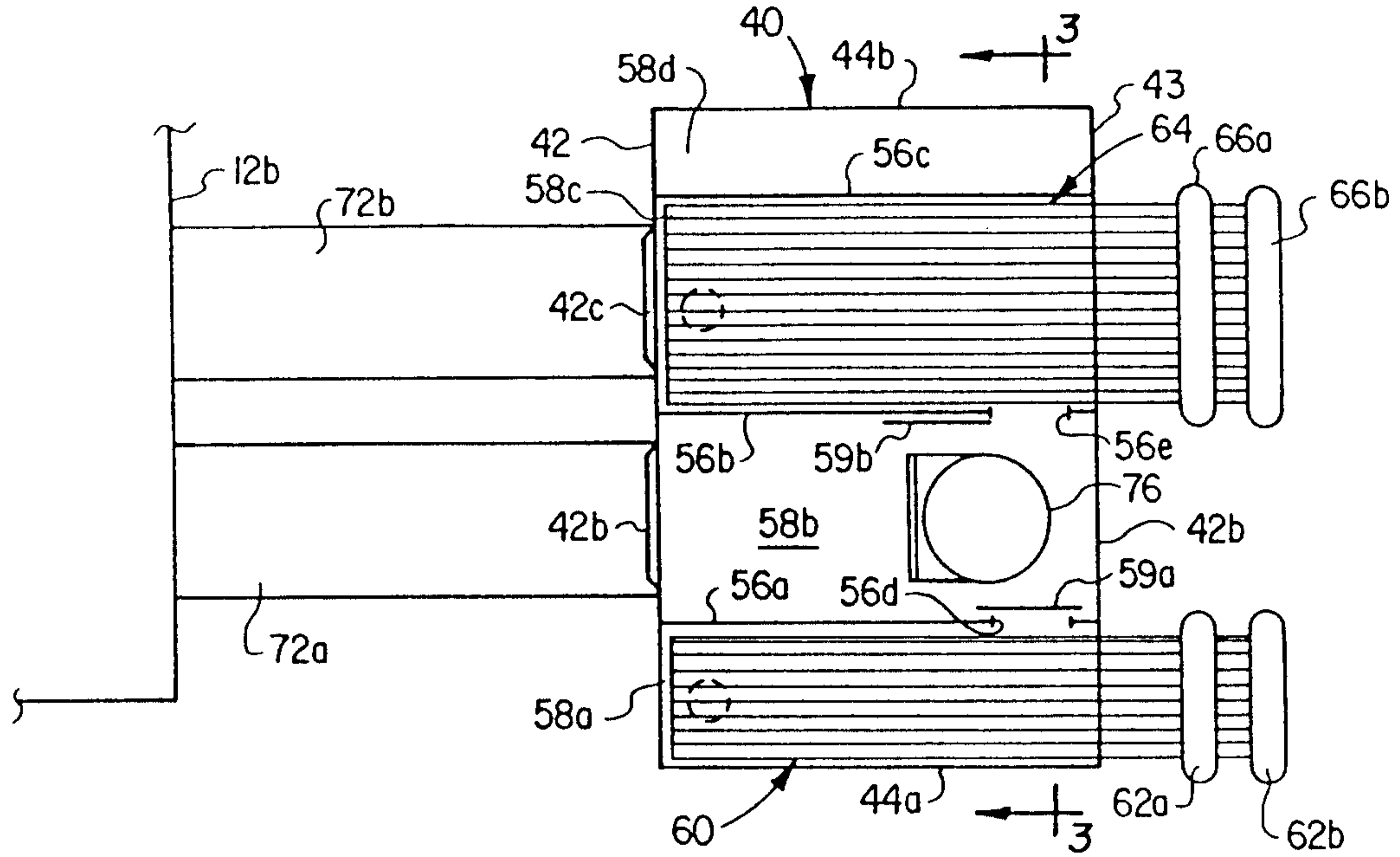


FIG. 2

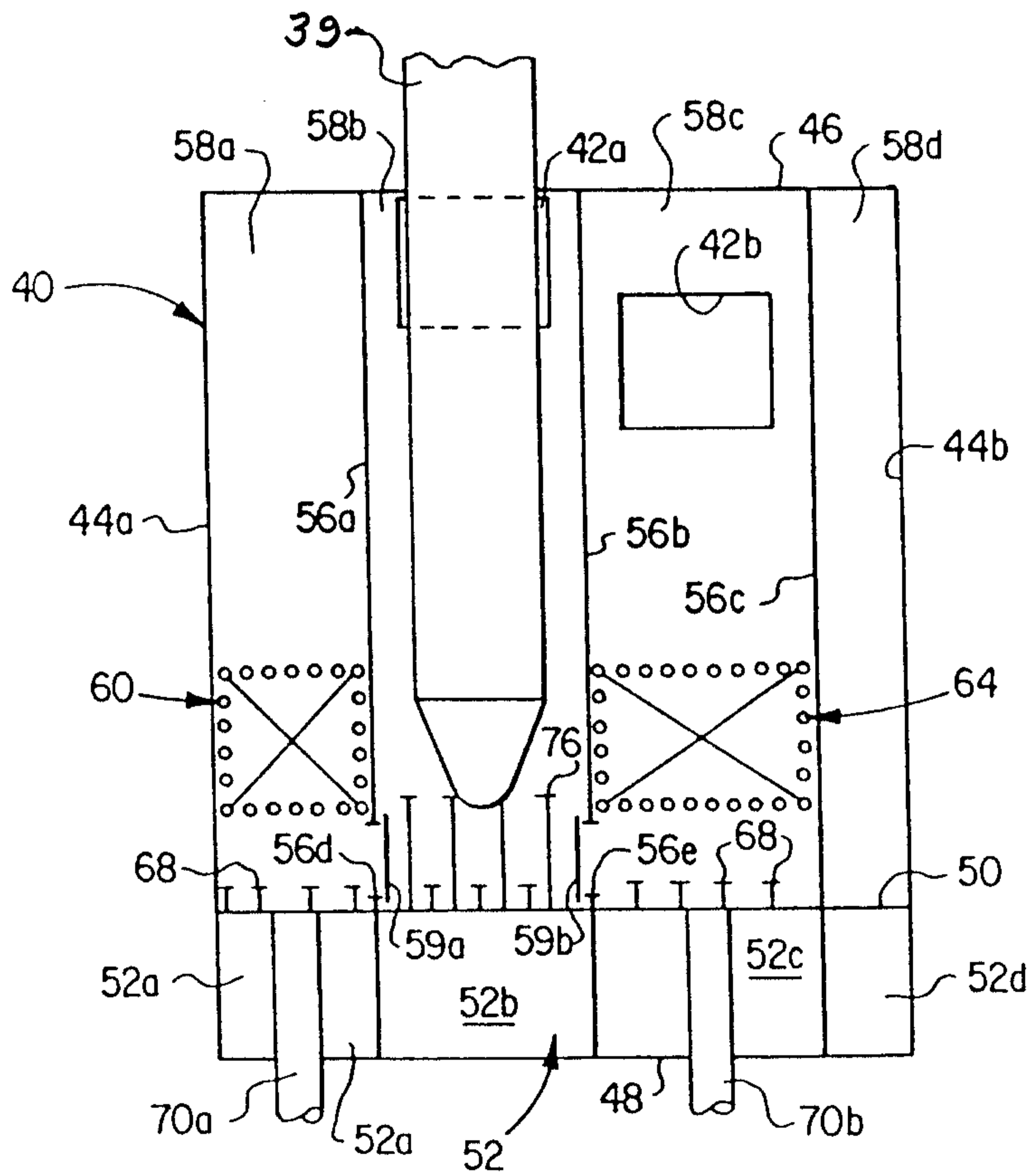


FIG. 3

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