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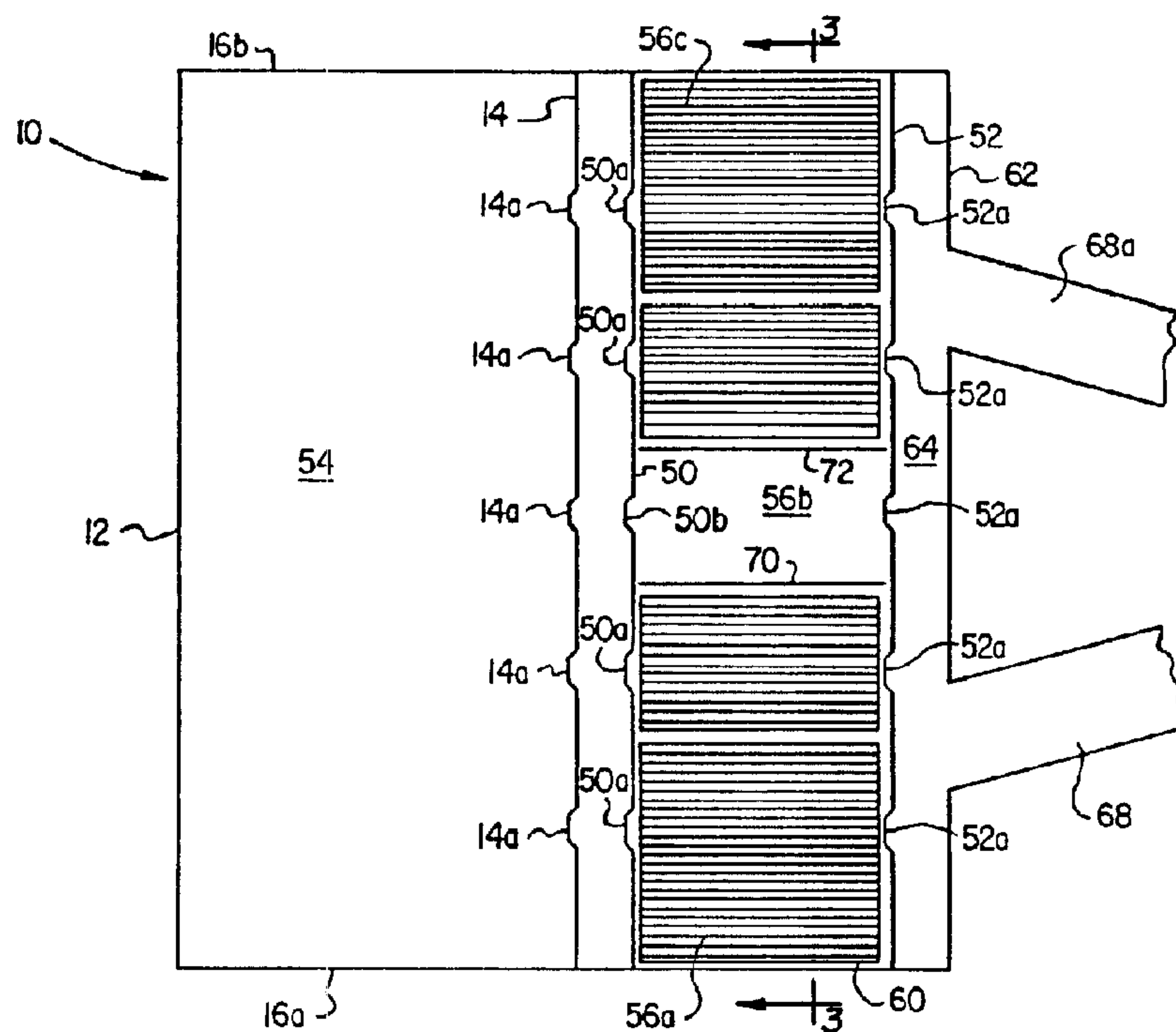
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(54) **SYSTEME ET METHODE DE COMBUSTION EN LIT FLUIDISE
A ECHANGEUR DE CHALEUR DE RECYCLAGE INTEGRE
FLUIDIZED BED COMBUSTION SYSTEM AND METHOD
HAVING AN INTEGRAL RECYCLE HEAT EXCHANGER
WITH INLET AND OUTLET CHAMBERS**



(57) A fluidized bed combustion system and method in which a recycle section is located within an enclosure housing the furnace section of the combustion system. The flue gases and entrained solids from a fluidized bed in the furnace section are separated and the flue gases are passed to a heat recovery section and the separated particulate material to the recycle heat exchanger. The recycle section includes a bypass chamber for permitting the separated solids to pass directly from the separator to the furnace section. A heat exchanger is provided in the recycle section to transfer heat from the separated material in the recycle section to a fluid flow circuit for controlling the temperature of the separated material. The separated material in the recycle section is then passed back to the furnace section.

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FLUIDIZED BED COMBUSTION SYSTEM AND METHOD
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EXCHANGER WITH INLET AND OUTLET CHAMBERS

Abstract of the Disclosure

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a recycle section is located within an enclosure housing
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FLUIDIZED BED COMBUSTION SYSTEM AND METHOD
HAVING AN INTEGRAL RECYCLE HEAT
EXCHANGER WITH INLET AND OUTLET CHAMBERS

Background of the Invention

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

10 Fluidized bed combustion systems are well known and 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
15 and to promote the combustion of the fuel at a relatively low temperature. These type 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 combination 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 "J" type of seal valve. This recycling improves the efficiency of the separator, and the resulting increase in the efficient use of sulfur adsorbent and fuel residence
5 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
10 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 (head) of the flue gases passed to the heat recovery area and the maximum heat capacity of
15 the separated solids recycled through the cyclone and to the furnace section are limited by this temperature. In a cycle not requiring 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
20 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
25 requires reheat duty as well as superheater duty, the

existing heat available in the flue gases at the furnace section outlet is not sufficient. 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 receives the separated solids from the separators and functions to remove heat from the solids at relatively high heat transfer rates before the solids are reintroduced to the furnace section, which heat is then transferred to cooling circuits in the heat recovery area. 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 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 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

- 5 -

path and from the heat exchanger path are recombined or each stream is directly routed to the furnace 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 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 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

- 6 -

exchanger which results in erratic performance. Also, the solids are directed from the heat exchanger to one relatively small area of the furnace section which is inconsistent with uniform mixing and distribution of the solids. Further, this system relies on pressure differential to drive the solids from the heat exchanger to the furnace section which requires power.

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 integrally with the furnace section of the combustion system in which heat is removed from the separated solids before they are recycled back to the furnace.

Further the present invention seeks to provide a system and method of the above type in which the heat removed from the separated solids in the recycle heat exchanger is used to provide the desired furnace temperature.

Still further 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.

Still further the present invention seeks to provide a system and method of the above type in which the heat removed from the separated solids in the recycle heat exchanger is transferred to fluid circulating in a heat exchange relation with the combustion system.

- 7 -

Still further the present invention seeks to provide a system and method of the above type in which the need for heat exchange surfaces in the heat recovery area of the combustion system is reduced.

Still 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, unit trip, and low load conditions.

Still further the present invention seeks to provide a system and method of the above type in which the recycle heat exchanger includes heat exchanger surfaces disposed between transverse inlet and outlet chambers to insure a uniform distribution of the separated solids through the recycle heat exchanger to increase the heat exchange efficiency and insure a uniform discharge of solids to the furnace.

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.

Still further the present invention seeks to provide a system and method of the above type in which the solids are driven from the recycle heat exchanger to the furnace by height differentials.

Still further the present invention seeks to provide a system and method of the above type in which a relative large space is available for the recycle heat exchanger surfaces.

- 8 -

The invention in one broad aspect pertains to a fluidized bed combustion system comprising a furnace containing a fluidized bed of particulate material, a separator 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 flue gases and a heat recovery section for receiving the separated flue gases from the separator and recovering heat from the separated flue gases. A recycle heat exchanger is disposed adjacent the furnace section and comprises a housing, a plurality of partitions for dividing the housing into an inlet chamber for receiving the separated material from the separator, an outlet chamber, a bypass compartment extending between the inlet chamber and the outlet chamber and at least one heat exchange compartment extending between the inlet chamber and the outlet chamber. Heat exchange means is disposed in the at least one heat exchange compartment for removing heat from the separated material and means is provided for selectively directing the separated material from the inlet chamber, through the at least one heat exchange compartment and to the outlet chamber or from the inlet chamber, through the bypass compartment and to the outlet chamber. Means connect the outlet chamber to the furnace section for passing the separated material to the furnace.

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 for transferring heat from the

solids to fluid passing through the system. Heat exchange surfaces are provided in the heat exchanger for removing heat from the solids and a bypass passage is provided through which the solids pass during start-up and low load conditions. Transverse inlet and outlet channels are provided in the heat exchanger for providing a uniform distribution of the separated solids through the heat exchanger and a uniform flow of solids to the furnace section. More than one bypass may be used and the location may be varied according to particular design and functional requirements.

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

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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

5 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 12, a rear wall 14 and two sidewalls 16a and 10 16b (Figs. 2 and 3). The upper portion of the enclosure 10 is enclosed by a roof 17 and the lower portion includes a floor 18.

 A plurality of air distributor nozzles 20 are mounted in corresponding openings found in a plate 22 extending 15 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 external sources (not shown) and selectively distribute the air through the plate 22 and to portions of the enclosure 10, as will be 20 described.

 A cool 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. The particulate material is 25 fluidized by the air from the plenum as it passes upwardly through the plate 22. This air promotes the combustion of

the fuel and the resulting 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 decreasing density column 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 16 of the enclosure 10 to an inlet provided through the separator wall. 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 particulate material 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.

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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
10 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 42 formed in the
rear wall thereof.

15 As shown in Fig. 1, the floor 18 and the plate 22 are
extended past the rear wall 14 and a pair of vertically
extending, spaced, parallel partitions 50 and 52 extend
upwardly from the floor 18. The upper portion of the
partition 50 is bent towards the wall 14 and then towards
20 the partition 52 with its upper end extending adjacent,
and slightly bent back from, the latter wall. Several
openings are provided through the wall 14 and the
partitions 50 and 52 to establish flow paths for the
solids, as will be described.
25

5 The front wall 12 and the rear wall 14 define a furnace section 54, the partitions 50 and 52 define a heat exchanger enclosure 56 and the rear wall 14 and the partition 50 define an outlet chamber 58 for the enclosure 56 which chamber is sealed off at its upper portion by the bent portion of the partition 50. A plurality of heat exchange tubes 60 are disposed in the heat exchanger enclosure 56 and will be described in detail later.

10 A sub-enclosure 62 is mounted on the outer surface of the partition 52 to define an inlet chamber 64 for the heat exchanger enclosure 56. The floor 18 and the plate 22 extend through the chamber 58, the enclosure 56 and the chamber 64 and the extended portion of the plate 22 contains addition nozzles 20. Thus the plenum 24 also
15 extends underneath the chambers 58 and 64 and the enclosure 56 for introducing air to the nozzles 20 located therein.

20 The lower portion of the separator 26 includes a hopper 26a which is connected to a dip leg 65 connected to the inlet "J" valve, shown in general by the reference numeral 66. The "J" valve 66 functions in a conventional manner to prevent back-flow of solids from the furnace section 54 to the separator 26. An inlet conduit 68
25 connects the outlet of the "J" valve 66 to the sub-enclosure 62 to transfer the separated solids from the

separator 26 to the inlet chamber 64 and the heat exchanger enclosure 56. The reference numeral 68a (Fig. 2) refers to the inlet conduit associated with an additional separator disposed behind the separator 26 but not shown in the drawings.

As shown in Figs. 2 and 3, the heat exchanger enclosure 56 is formed into three compartments 56a, 56b and 56c by a pair of transverse spaced partitions 70 and 72 extending between the partition 52 and the rear wall 14. The aforementioned heat exchange tubes 60 are shown schematically in Figs. 2 and 3, and are located in the compartments 56a and 56c where they are divided into two groups 60a and 60. The partitions 70 and 72 also divide the plenum 24 into three sections 24a, 24b and 24c extending immediately below the heat exchanger compartments 56a, 56b and 56c, respectively. It is understood that means, such as dampers, or the like, (not shown) can be provided to selectively distribute air to the individual sections 24a, 24b and 24c.

Five spaced openings 52a (Fig. 2) are formed in the lower portion of the partition 52 and four spaced openings 50a (Figs. 2 and 3) are formed in an intermediate portion of those portions of the partition 50 defining the compartments 56a and 56c. An opening 50b is also formed in that portion of the partition 50 defining the

compartment 56b and extends at an elevation higher than the openings 52a (Figs. 2 and 3). Five spaced openings 14a (Figs. 1 and 2) are formed in the lower portion of the rear wall and five spaced openings 14b (Fig. 1) are
5 provided through the upper portion of the latter partition.

The front wall 12, the rear wall 14, the sidewalls 16a and 16b, the partitions 50, 52, 70, and 72, the roof 17, the walls of the sub-enclosure 62 and the walls defining the heat recovery enclosure 34 all are formed of
10 membrane-type walls an example of which is depicted in Fig. 4. As shown, each wall is formed by a plurality of finned water tubes 74 disposed in a vertically extending, air tight relationship with adjacent finned tubes being connected along their lengths.

15 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 the various walls described above. Also, a plurality of downcomers, pipes, etc. are utilized to establish a flow
20 circuit including the tubes 74 forming the aforementioned water tube walls, the headers, the steam drum 80, the heat exchanger tubes 60 and the tubes forming the reheater 36, the superheater 37 and economizer 38. Water is passed, in
25 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 furnace section 54.

5 In operation, particulate fuel material and a sorbent material (hereinafter referred to as "solids") are introduced into the furnace section 54 through the feeder system 25. Air from an external source is introduced at a sufficient pressure into that portion of the plenum 24 extending below the furnace section 54 and the air passes through the nozzles 20 disposed in the furnace section 54 at a sufficient quantity and velocity to fluidize the solids in the latter section.

10 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 mixture of air and gaseous products of combustion (hereinafter referred to as "flue gases") passes upwardly through the furnace section 54 and entrains, or elutriates, 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 furnace section 54 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 furnace section 54 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 furnace section 54, decreases with height throughout the length of the latter section and is substantially constant and relatively low in the upper portion of the section.

The saturated flue gases in the upper portion of the furnace section 54 exit into the duct 28 and pass into the cyclone separator(s) 26. In each separator 26, the solids are separated from the flue gases and the former passes from the separator through the dipleg 65 and is injected, via the "J" valve 66 and the conduit 68, into the inlet chamber 64. The cleaned flue gases from the separator 26 exit, via 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 42 to external equipment.

Normally, the separated solids from the conduit 68 enter the inlet chamber 64 and pass, via the openings 52a in the partition 52 into the heat exchanger enclosure 56. Air is introduced into the section of the plenum 24 below the chambers 58 and 64 and the enclosure 56 (Fig. 1). In the enclosure 56 the air passes into the plenum sections

24a and 24c (Fig. 3) and is discharged through the corresponding nozzles 20. Thus the solids in the chambers 58 and 64 and in the compartments 56a and 56c are fluidized. The solids in the compartments 56a and 56c pass in a generally upwardly direction across the heat exchange tubes 60a and 60b in each compartment before exiting, via the openings 50a into the chamber 58 (Figs. 1 and 2). The solids mix in the chamber 58 before they exit, via the lower openings 14a formed in the rear wall 14, back into the furnace section 54.

The five openings 14b provided through the upper portion of the rear wall 14 equalize the pressure in the chamber 58 to the relatively low pressure in the furnace section 54. Thus the level establishes a solids head differential which drives the solids through the openings 14a without relying on the fluidizing air pressure.

It is understood that a drain pipe or the like may be provided on the plate 22 as needed for discharging spent solids from the furnace section 54 and the heat exchanger enclosure 56 as needed.

Fluid is circulated through the flow circuit described above in a predetermined sequence to convert the fluid to steam and to reheat and superheat the steam. To this end, the heat removed from the solids in the heat exchanger 56 can be used to provide reheat and/or full or

partial superheat. In the latter context the two groups of tubes 60a and 60b in each of the heat exchanger sections 56a and 56c can function to provide intermediate and finishing superheating, respectively, while the primary superheating is performed in the heat recovery area 32.

Since, during the above operation, fluidizing air is not introduced into the air plenum section 24b associated with the heat exchanger section 56b, and since the opening 50b in the partition 50 is at a greater height than the openings 50a, very little, if any, flow of solids through the heat exchanger section 56b occurs. However, during initial start up and low load conditions the fluidizing air to the plenum section 24b is turned on while the air flow to the sections 24a and 24c is turned off. This allows the solids in the heat exchanger sections 56a and 56c to slump and therefore seal this volume from further flow, while the solids from the inlet chamber 64 pass directly through the heat exchanger section 56b to the outlet chamber 58 and to the furnace section 54. Since the section 56b does not contain heat exchanger tubes, it functions as a bypass so that start up and low load operation can be achieved without exposing the heat exchanger surface 56a and 56c to the hot recirculating solids.

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 furnace section 54, 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. Also, the heat exchange efficiency in the enclosure 56 is increased and a uniform discharge of solids to the furnace is insured due to the uniform distribution and flow of the separated solids through the chambers 58 and 64 and the enclosure 56. Also, the recycled solids can be passed directly from the "J" valve 66 to the furnace section during start-up or low load conditions prior to establishing adequate cooling steam flow to the enclosure sections 56a and 56c. Also, the recycle heat exchanger enclosure 56 is formed integrally with the furnace section 54 which improves heat transfer efficiency. Further, the recycle heat exchanger enclosure 56 is isolated from pressure fluctuations in the furnace and the solids are driven from the enclosure 56 and the chambers 64 and 58 by height differentials which reduces the overall power requirements. Also, a relative large

space is provided in the enclosure sections 56a and 56c compartment for accommodating the heat exchange tubes.

5 It is understood that several variations may be made in the foregoing without departing from the scope of the present invention. For example, a conduit 82 can be provided in the upper portion of the partition 50 which extends into an opening formed through the rear wall 14 to equalize the pressure in the chamber 58 to the relatively low pressure in the furnace section 54. Thus the conduit can be used in addition to, or in place of, the openings 10 14b in the rear wall 14. Also, the heat removed from the solids in the recycle heat exchanger enclosure can be used for heating the system fluid in the furnace section or the economizer, etc. Also, other types of beds may be 15 utilized in the furnace such as a circulating bed with constant density through its entire length or a bubbling bed, etc. Further, the number and/or location of the bypass channels in the recycle heat exchanger can be varied.

20 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 25 and in a manner consistent with the scope of the invention.

- 22 -

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:
 - a furnace containing a fluidized bed of particulate material;
 - a separator for receiving a mixture of flue gases and entrained particulate material from the fluidized bed in said furnace section and separating said entrained particulate material from said flue gases;
 - a heat recovery section for receiving the separated flue gases from the separator and recovering heat from said separated flue gases;
 - a recycle heat exchanger disposed adjacent said furnace section and comprising:
 - a housing;
 - a plurality of partitions for dividing said housing into an inlet chamber for receiving said separated material from said separator, an outlet chamber, a bypass compartment extending between said inlet chamber and said outlet chamber and at least one heat exchange compartment extending between said inlet chamber and said outlet chamber;
 - heat exchange means disposed in said at least one heat exchange compartment for removing heat from said separated material;
 - means for selectively directing said separated material from said inlet chamber, through said at least one heat exchange compartment and to said outlet chamber or from said inlet chamber, through said bypass compartment and to said

- 23 -

outlet chamber; and

means connecting said outlet chamber to said furnace section for passing said separated material to said furnace.

2. The system of claim 1 wherein said outlet chamber extends between said compartments and said furnace.

3. The system of claim 1 wherein said directing means comprises means connecting said inlet chamber to said compartments, means connecting said compartments to said outlet chamber and means connecting said outlet chamber to said furnace section.

4. The system of claim 3 wherein said connecting means comprises openings formed through said partitions.

5. The system of claim 1 wherein said directing means comprises means responsive to start-up and low load conditions for passing said separated material through said bypass compartment and means responsive to full-load conditions for passing said separated material through said at least one heat exchange compartment.

6. The system of claim 1 wherein said directing means comprises means for selectively introducing air to said bypass compartment or to said heat exchange compartment to fluidize the separated material therein to permit the flow of said separated material through said bypass compartment or through said heat exchange compartment, respectively.

- 24 -

7. The system of claim 1 further comprising means for introducing air into at least one of said chambers to fluidize the separated material in said chambers.

8. The system of claim 1 wherein at least a portion of the walls of said furnace are formed by tubes and further comprising fluid flow circuit means for passing fluid through said tubes to transfer heat generated in said furnace to said fluid.

9. The system of claim 8 wherein said flow circuit means further comprises means for passing said fluid through said heat exchange means in a heat exchange relation to the material in the at least one heat exchange compartment to transfer heat from said separated material in said latter compartment to said fluid to control the temperature of the separated material.

10. The system of claim 1 wherein the separated material in said compartments seals against the backflow of material from said furnace to said separator.

11. The system of claim 1 further comprises means for equalizing the pressure in said furnace and said recycle heat exchanger.

12. The system of claim 11 wherein said pressure equalizing means comprises openings formed through the partitions extending between said furnace and said outlet chamber.

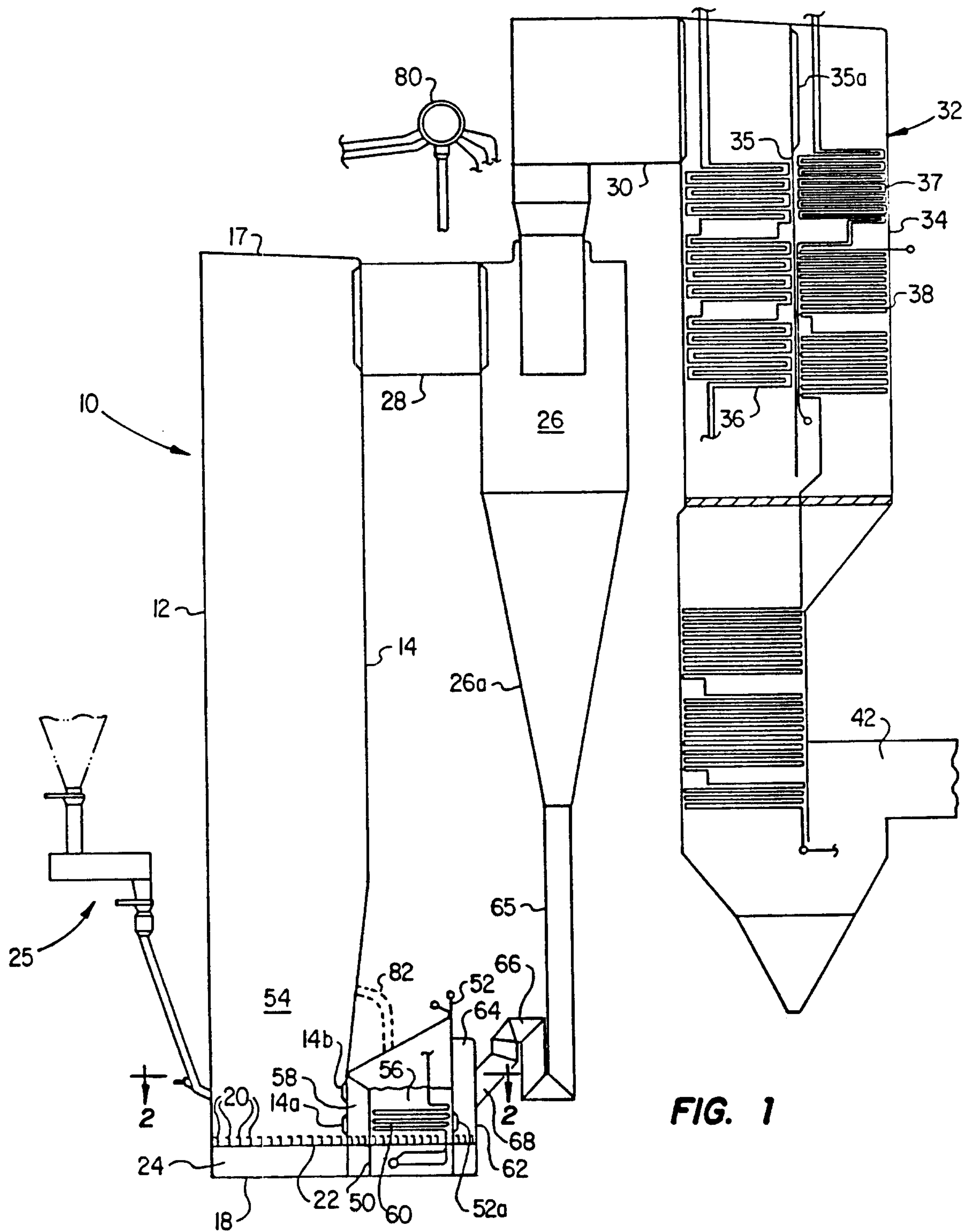


FIG. 1

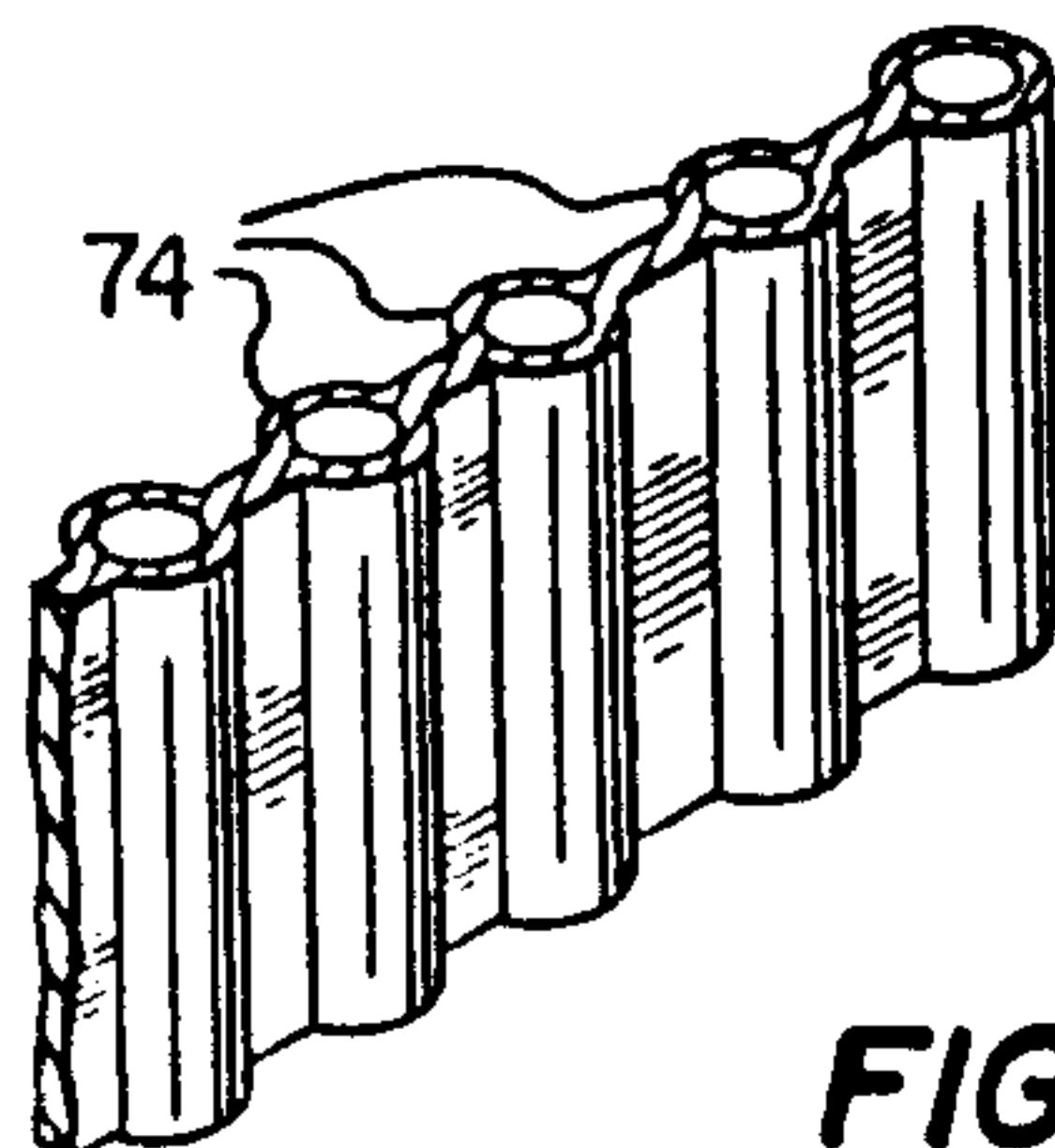


FIG. 4

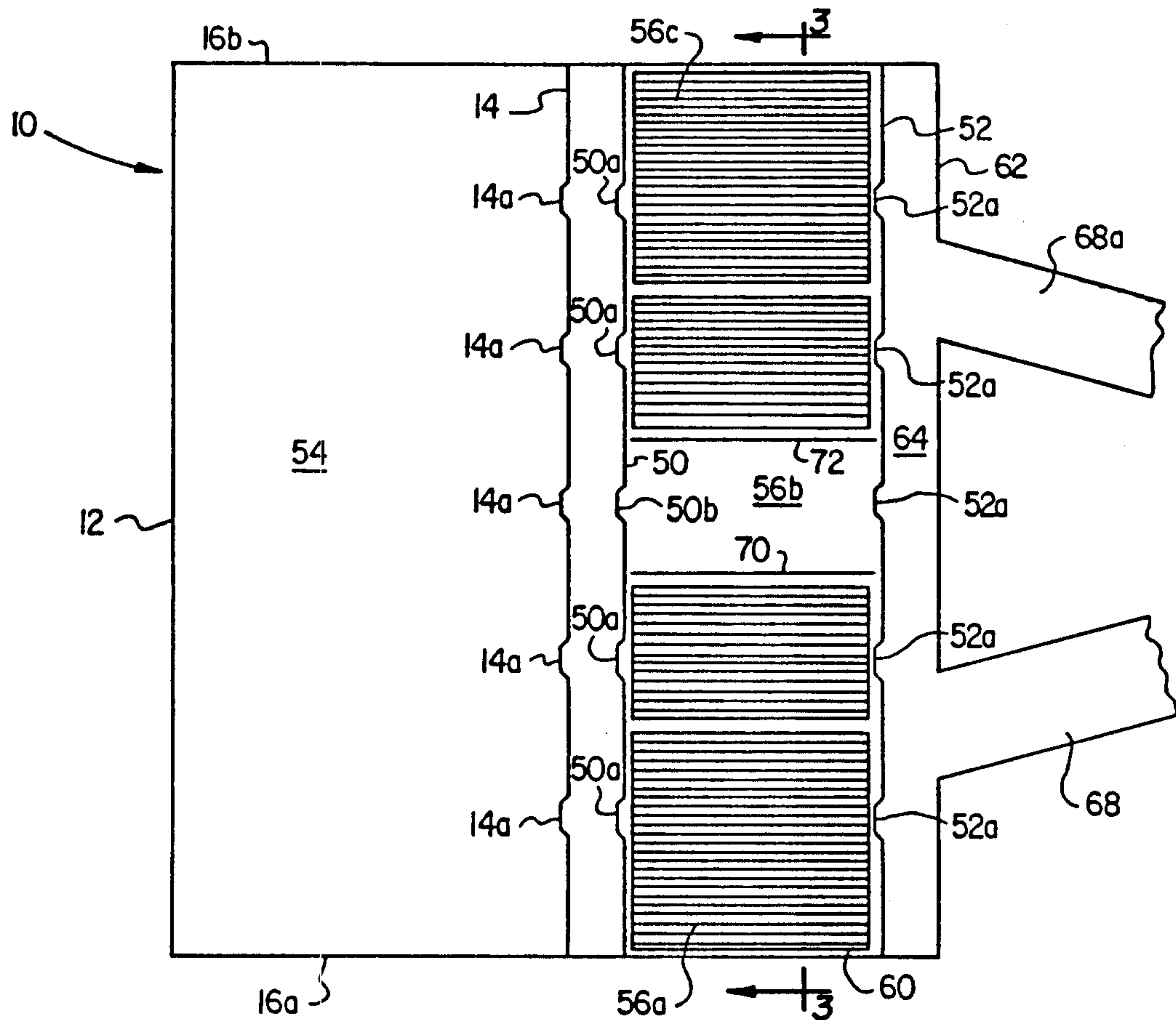


FIG. 2

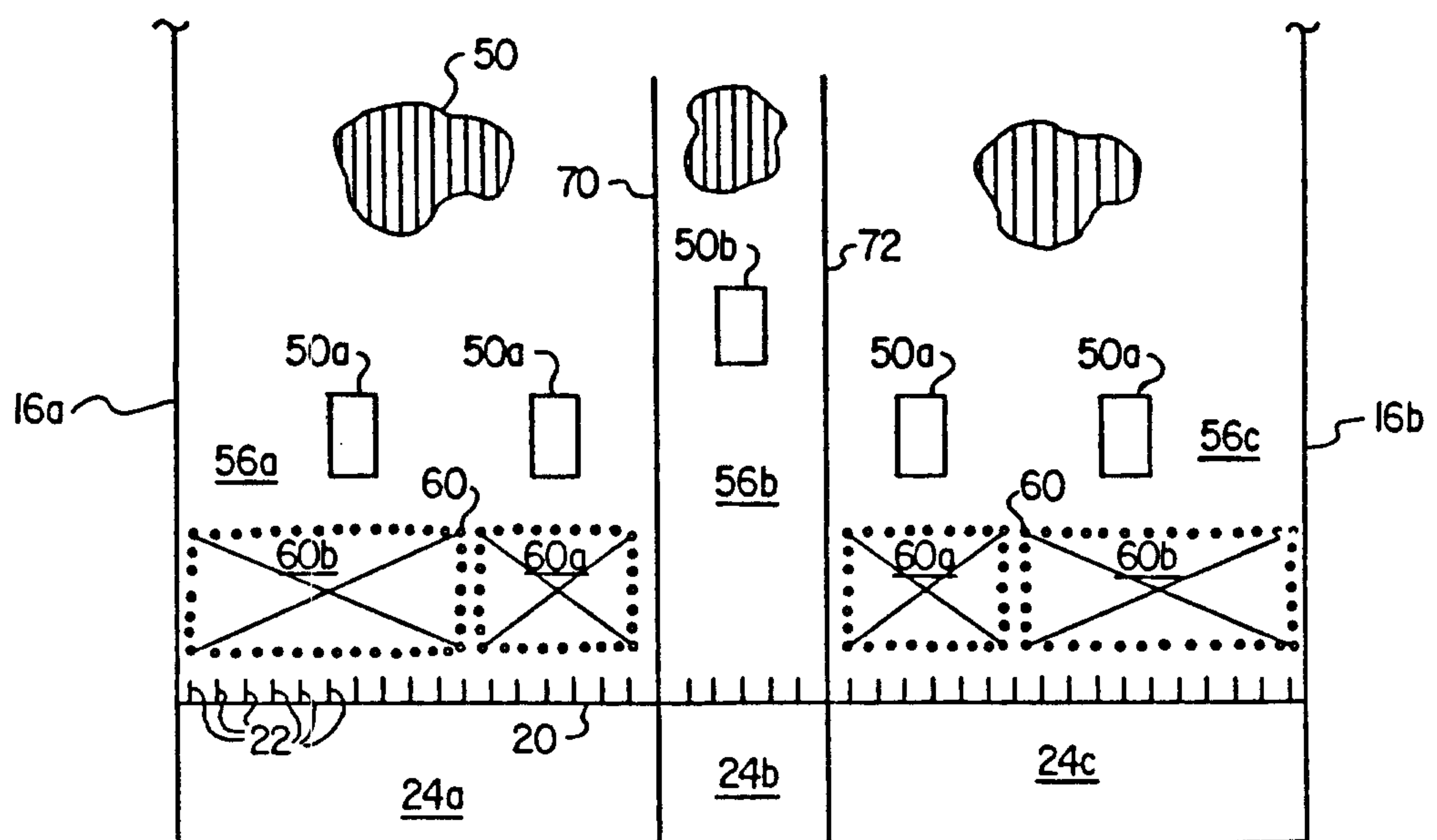


FIG. 3

