



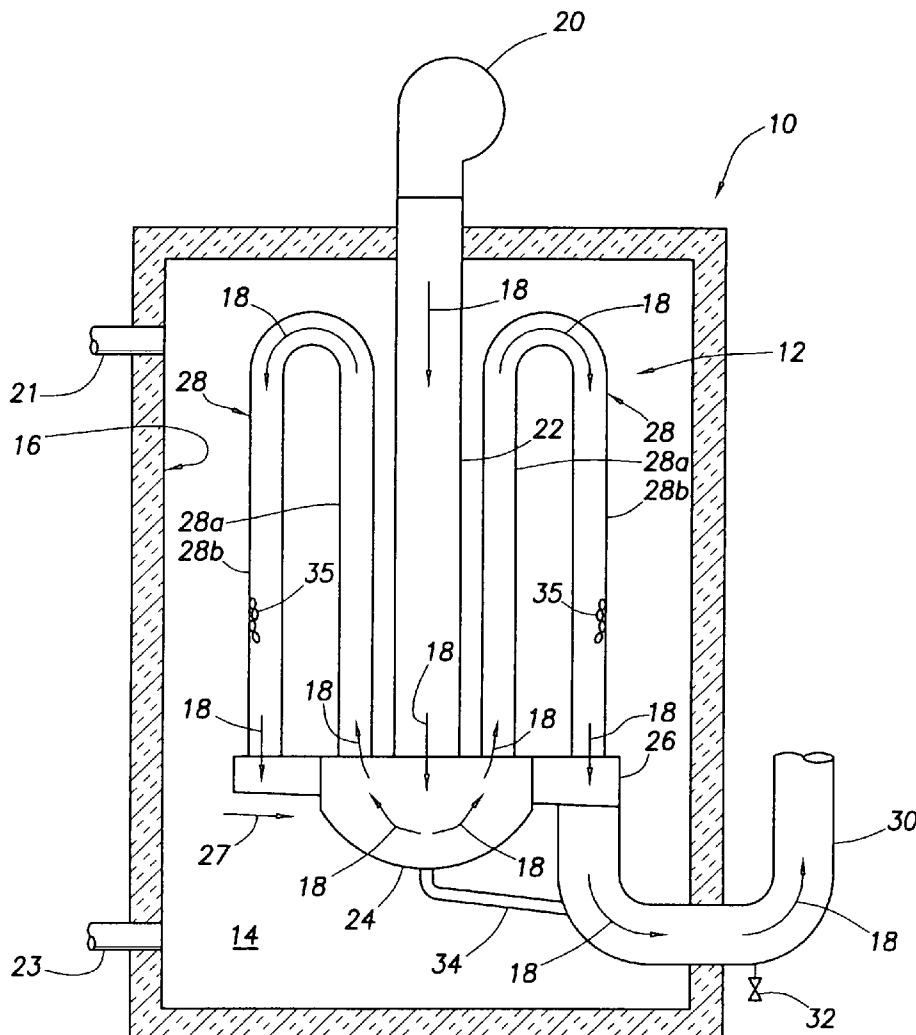
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(19) **United States**(12) **Patent Application Publication**
Missoum et al.(10) **Pub. No.: US 2007/0051359 A1**(43) **Pub. Date: Mar. 8, 2007**(54) **LOOPED SYSTEM FUEL-FIRED FLUID
HEATING/STORAGE DEVICE****Publication Classification**(51) **Int. Cl.**
F24H 3/06 (2006.01)(52) **U.S. Cl.** **126/110 R**(76) **Inventors:** **Ozzie Missoum**, Pike Road, AL (US);
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(21) **Appl. No.: 11/222,350**(22) **Filed: Sep. 8, 2005**(57) **ABSTRACT**

A fuel-fired commercial water heater has a three-pass condensing type heat exchanger disposed within its tank and having a vertical flue connected at its lower end to a central collector plenum horizontally circumscribed by an outer plenum to which an exhaust pipe is coupled. A series of vertical tube structures are disposed above and intercommunicate the central and outer collector plenums. The outlet of a fuel burner is coupled to the upper end of the flue and is operative to sequentially flow combustion gases downwardly through the flue into the central collector plenum, upwardly and then downwardly through the tube structures into the outer collector plenum and then outwardly through the exhaust pipe.



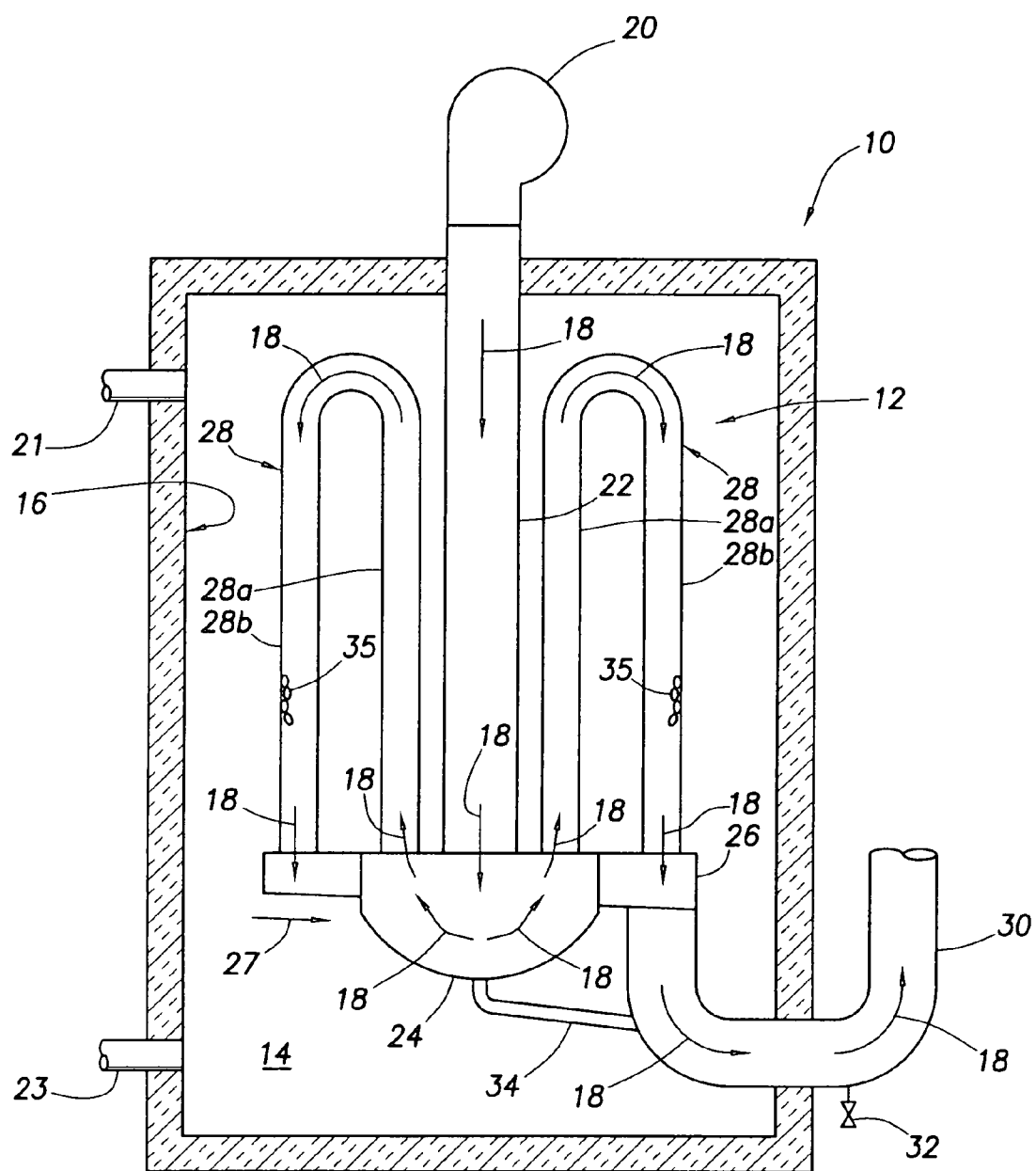


FIG. 1

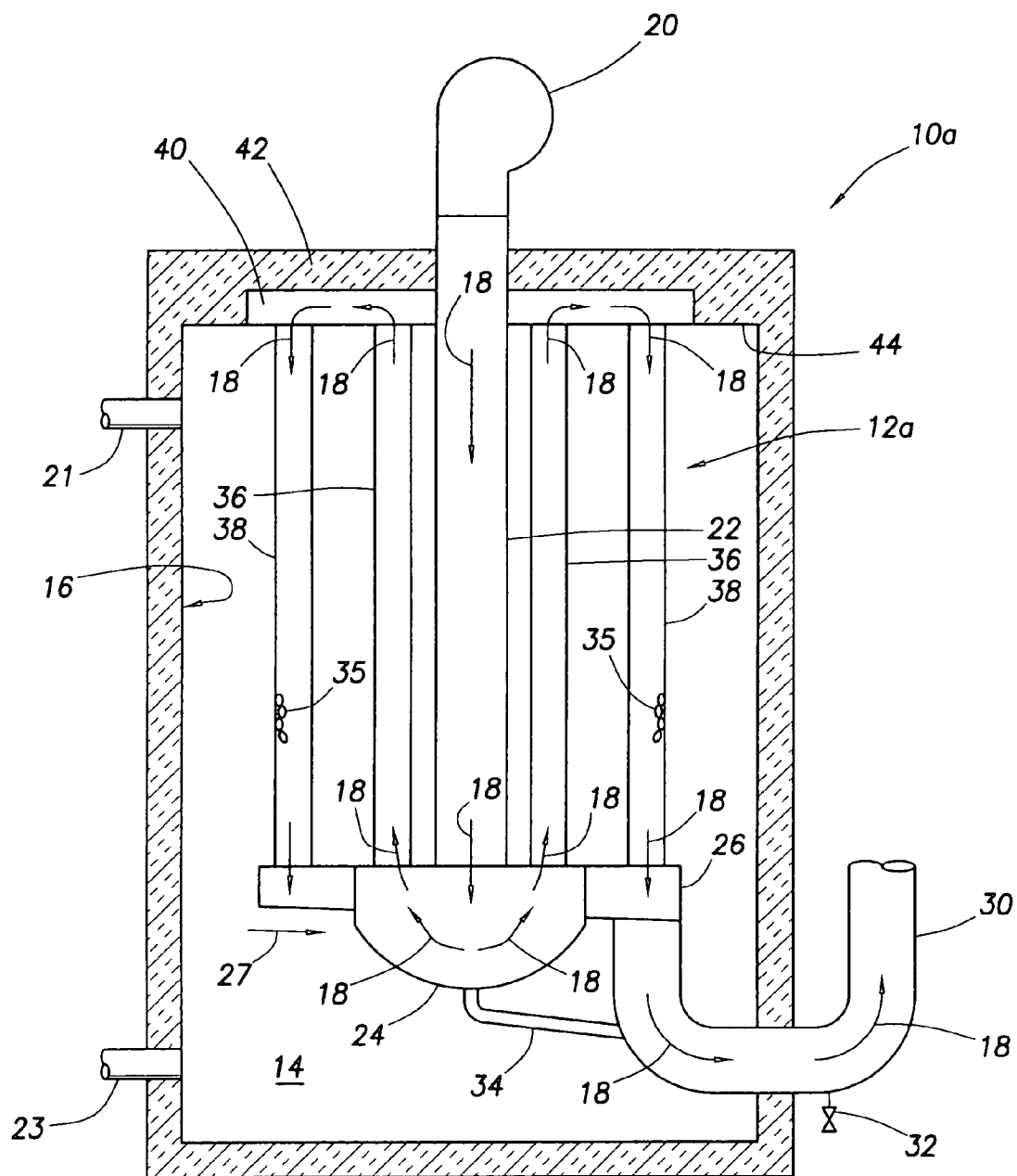


FIG. 2

LOOPED SYSTEM FUEL-FIRED FLUID HEATING/STORAGE DEVICE

BACKGROUND OF THE INVENTION

[0001] The present invention generally relates to fuel-fired fluid heating devices and, in representatively illustrated embodiments thereof, more particularly provides a fuel-fired water heater having a specially designed multi-pass condensing type heat exchanger incorporated therein.

[0002] Conventional fuel-fired water heaters are typically of a "single pass", non-condensing configuration, meaning that the hot combustion gases used to heat the tank-stored water are subjected to only a single pass through a heat exchanger structure (usually a vertical flue) within the tank before being discharged from the water heater to, for example, an external vent structure, and that flue gas condensation does not occur to any appreciable degree in the heat exchanger structure within the water heater tank. In this conventional type of fuel-fired water heater, the overall thermal efficiency is typically limited to about 80-85%. Various proposals have been made to provide fuel-fired water heaters with condensing type single-pass heat exchangers (i.e., in which flue gases condense within the heat exchanger). However, previously proposed single-pass condensing type heat exchange structures incorporated in fuel-fired water heaters typically provide the water heaters with thermal efficiencies limited to the 85-90% range.

[0003] In an attempt to increase this thermal efficiency to above 95%, multi-pass condensing heat exchangers of varying configurations and types have been proposed for installation within the tank portions of fuel-fired water heaters. While such previously proposed multi-pass condensing type heat exchangers have met this thermal efficiency goal, they have also undesirably presented various problems, limitations and disadvantages. These include increased heat exchanger complexity, higher material and fabrication costs, condensate management problems, increased operational noise, and reduced heat exchanger operational life.

[0004] It would thus be desirable to provide a fuel-fired water heater, or other type of fuel-fired fluid heating device, with an improved multi-pass condensing type heat exchanger. It is to this goal that the present invention is primarily directed.

SUMMARY OF THE INVENTION

[0005] In carrying out principles of the present invention, in accordance with representative embodiments thereof, a fuel-fired fluid heating apparatus is provided that is representatively a fuel-fired commercial water heater, but could alternatively be another type of fuel-fired water heater or another type of fuel-fired fluid heating apparatus such as, for example, a boiler.

[0006] In general, the apparatus comprises a tank for holding a fluid to be heated, and a heat exchanger disposed in the tank and having an interior combustion gas flow path defined by (1) a first pass section having an inlet portion and an outlet portion spaced apart from the inlet portion of the first pass section in a first direction, (2) a central collector plenum coupled to the outlet portion of the first pass section, (3) a second pass section having an inlet portion coupled to the central collector plenum and an outlet portion spaced

apart from the inlet portion of the second pass section in a second direction opposite from the first direction, (4) a third pass section having an inlet portion coupled to the outlet portion of the second pass section and an outlet portion spaced apart from the inlet portion of the third pass section in the first direction, (5) an outer collector plenum circumscribing the collector plenum and being coupled to the outlet portion of the third pass section, and (6) an exhaust section coupled to the outer collector plenum. Additionally, the apparatus comprises a combustion system operative to flow hot combustion gases into the inlet portion of the first pass section and then through the balance of the heat exchanger.

[0007] In a first embodiment thereof, the apparatus is a fuel-fired water heater comprising a tank for holding water to be heated, and a condensing type multi-pass heat exchanger disposed within the tank. The heat exchanger includes (1) a vertically extending flue having an upper inlet end and a lower outlet end, (2) a central collector plenum coupled to the lower outlet end of the flue, (3) an outer collector plenum horizontally circumscribing the central collector plenum, (4) a plurality of vertically extending inverted U-tubes horizontally spaced around the flue, each inverted U-tube having a lower inlet end coupled to the central collector plenum, and a lower outlet end coupled to the outer collector plenum, and (5) an exhaust pipe having an inlet portion coupled to the outer collector plenum. The water heater also comprises a fuel burner (which may be either a powered fuel burner or a non-powered burner) having an outlet coupled to the upper inlet end of said flue, the fuel burner being operative to flow combustion gases through the flue and then the balance of the condensing type heat exchanger.

[0008] In a second embodiment thereof, the apparatus is a fuel-fired water heater comprising a tank for holding water to be heated, a transfer plenum disposed exteriorly of the tank at an upper end portion thereof, and a condensing type multi-pass heat exchanger disposed within the tank. The heat exchanger includes (1) a vertically extending flue having an upper inlet end and a lower outlet end, (2) a central collector plenum coupled to said lower outlet end of said flue, (3) an outer collector plenum horizontally circumscribing the central collector plenum, (4) a first plurality of vertical tubes horizontally spaced around the flue and having lower inlet ends coupled to the central collector plenum, and upper outlet ends coupled to the transfer plenum, (5) a second plurality of vertical tubes disposed horizontally outwardly of and horizontally spaced around the first plurality of vertical tubes, the second plurality of vertical tubes having upper inlet ends coupled to the transfer plenum, and lower outlet ends coupled to the outer collector plenum, and (6) an exhaust pipe having an inlet portion coupled to the outer collector plenum. The water heater also comprises a fuel burner (which may be either a powered fuel burner or a non-powered fuel burner) having an outlet coupled to the upper inlet end of the flue, the fuel burner being operative to flow combustion gases through the flue and then the balance of the condensing type heat exchanger.

[0009] According to other aspects of the invention a portion of the central collector plenum extends downwardly past the outer collector plenum, the outer collector plenum has vertically sloped lower side having a lowermost portion to which an inlet portion of the exhaust pipe is connected, the bottom side of the central collector plenum has a

downwardly domed configuration, and a sloped condensate drain line extends within the tank from the bottom side of the central collector plenum to an inlet portion of the exhaust pipe within the tank.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a schematic cross-sectional view through a representative fuel-fired water heater having incorporated therein a specially designed condensing type multi-pass heat exchanger embodying principles of the present invention; and

[0011] FIG. 2 is a schematic cross-sectional view through an alternate embodiment of the FIG. 1 water heater.

DETAILED DESCRIPTION

[0012] Schematically illustrated in cross-section in FIG. 1 is a looped system fuel-fired fluid heating/storage device embodying principles of the present invention, the device representatively being a fuel-fired commercial water heater 10 having a specially designed condensing type multi-pass heat exchanger 12 submerged in the pressurized stored water 14 in an externally insulated tank portion 16. As used herein the term "commercial" water heater means, as commonly accepted in the water heater industry, a water heater having a firing input rate typically above about 75,000 Btu/Hr., and a heated water temperature of about 180° F. or above. While the illustrated device 10 is representatively a commercial water heater, it could alternatively be a non-commercial water heater, or another type of fuel-fired fluid heating device, such as for example, a boiler, without departing from principles of the present invention.

[0013] During firing of the water heater 10, hot flue gases 18 from a fuel burner 20 atop the water heater are flowed through the heat exchanger 12 to transfer combustion heat, with a thermal efficiency of 95% or above, to the stored water 14. Burner 20 may be either a powered fuel burner or a non-powered fuel burner. On demand, pressurized heated water 14 stored in the tank 16 may be withdrawn therefrom through a tank-mounted outlet fitting 21. Automatically, the withdrawn water 14 is replaced with pressurized cold water, from a source thereof, through a tank-mounted inlet fitting 23.

[0014] The heat exchanger 12 is of a three-pass configuration and includes a vertical flue portion 22 connected at its upper end to the outlet of the burner 20 and connected at its lower end to an inverted dome-shaped central primary flue gas collector plenum 24 horizontally circumscribed by an annular secondary flue gas collector plenum 26 that has a bottom wall which is vertically sloped downwardly and rightwardly as indicated by the slope arrow 27 in FIG. 1. A series of vertically extending inverted U-tubes 28 (only two of which are shown in FIG. 1) are spaced around the central flue 22. Each inverted U-tube 28 has one leg 28a connected to and communicated with the central plenum 24 and another leg 28b connected to the annular outer plenum 26 as shown. A combustion gas exhaust pipe 30 is connected to the underside of the annular plenum 26 and has, external to the water heater, a condensate drain fitting 32. A submerged condensate line 34 is interconnected between the underside of the central plenum 24 and an inlet portion of the exhaust pipe 30 as shown.

[0015] During firing of the water heater 10, the flue gas 18 discharged from the burner 20 sequentially makes a first pass downwardly through the vertical central flue portion 22, a second pass from the central plenum 24 upwardly through the U-tube legs 28a, and a third pass downwardly through the U-tube legs 28b into the annular outer plenum 26, with condensation 35 from the flue gas 18 being formed within the U-tube legs 28b as shown. Condensate from the annular plenum 26 flows into the exhaust pipe 30, and any condensate which may be in the central plenum 24 also flows into the exhaust pipe 30 via the submerged, sloped condensate line 34.

[0016] The modified water heater 10a shown in FIG. 2 is identical to the FIG. 1 water heater 10 with the exception that in the modified heat exchanger 12a the inverted U-tubes 28 (see FIG. 1) are replaced with straight vertical second pass tubes 36 and straight vertical third pass tubes 38. As illustrated in FIG. 2, the second pass tubes 36 are interconnected between the plenum 24 and an upper transfer plenum 40 disposed in insulation 42 above the top end 44 of the top of the tank 16, and the third pass tubes 38 are interconnected between the plenums 26 and 40.

[0017] During firing of the water heater 10a, flue gases 18 from the burner 20 sequentially flow downwardly through the vertical central flue portion 22 into the central plenum 24, upwardly from the plenum 24 through the vertical tubes 36 into the top plenum 40, and then downwardly from the top plenum 40 through the vertical tubes 38 into the bottom annular plenum 26 from which they are discharged via the exhaust pipe 30. Condensate 35 formed in the third pass tubes 38 is discharged from the heat exchanger 12a in a manner similar to that previously described in conjunction with the FIG. 1 heat exchanger 12.

[0018] Compared to conventional multi-pass condensing type heat exchangers utilized in fuel-fired water heaters, the heat exchangers 12, 12a representatively illustrated and described herein provide a variety of advantages which may include, for example, the capability of providing their associated water heaters with thermal efficiencies well above 95%, simplified heat exchanger configuration, reduced material and fabrication costs, quieter operation, increased heat exchanger life, and improved condensate management.

[0019] As will be readily appreciated by those of skill in this particular art, the representatively illustrated heat exchangers 12 and 12a, could have other orientations within their associated water heaters 10 and 10a without departing from principles of the present invention. For example, the heat exchangers 12 and 12a, with minor modifications thereto, could alternatively be horizontally oriented within their associated water heaters 10 and 10a.

[0020] The foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the present invention being limited solely by the appended claims.

What is claimed is:

1. A fuel-fired fluid heating apparatus comprising:

a tank for holding a fluid to be heated;

a heat exchanger disposed in said tank and having an interior combustion gas flow path defined by:

a first pass section having an inlet portion and an outlet portion spaced apart from said inlet portion of said first pass section in a first direction,

a central collector plenum coupled to said outlet portion of said first pass section,

a second pass section having an inlet portion coupled to said central collector plenum and an outlet portion spaced apart from said inlet portion of said second pass section in a second direction opposite from said first direction,

a third pass section having an inlet portion coupled to said outlet portion of said second pass section and an outlet portion spaced apart from said inlet portion of said third pass section in said first direction,

an outer collector plenum circumscribing said collector plenum and being coupled to said outlet portion of said third pass section, and

an exhaust section coupled to said outer collector plenum; and

a combustion system operative to flow hot combustion gases into said inlet portion of said first pass section and then through the balance of said flow path.

2. The fuel-fired fluid heating apparatus of claim 1 wherein:

said fuel-fired fluid heating apparatus is a fuel-fired water heater.

3. The fuel-fired fluid heating apparatus of claim 1 wherein:

said heat exchanger is a condensing type heat exchanger.

4. The fuel-fired fluid heating apparatus of claim 1 wherein:

said combustion system includes a fuel burner having an outlet coupled to said inlet portion of said first pass section.

5. The fuel-fired fluid heating apparatus of claim 1 wherein:

said first direction extends generally downwardly, and

said second direction extends generally upwardly.

6. The fuel-fired fluid heating apparatus of claim 5 wherein:

said outer collector plenum has a vertically sloped bottom side with a lowermost portion, and

said exhaust section has an inlet portion coupled to said lowermost portion.

7. The fuel-fired fluid heating apparatus of claim 6 further comprising:

a condensate drain line interconnected between a bottom side portion of said central collector plenum and said exhaust section.

8. The fuel-fired fluid heating apparatus of claim 5 wherein:

said central collector plenum extends downwardly beyond said outer collector plenum.

9. The fuel-fired fluid heating apparatus of claim 8 wherein:

said central collector plenum has a domed bottom side.

10. The fuel-fired fluid heating apparatus of claim 1 wherein:

said central collector plenum extends past said outer collector plenum in said first direction.

11. The fuel-fired fluid heating apparatus of claim 1 wherein:

said second and third pass sections are at least partially defined by a U-tube structure extending parallel to said first pass section and having a first open end coupled to said central collector plenum, and a second open end coupled to said outer collector plenum.

12. The fuel-fired fluid heating apparatus of claim 1 wherein:

said second and third pass sections are defined by a plurality of U-tube structures circumferentially spaced around and extending parallel to said first pass section, each of said U-tube structures having a first open end coupled to said central collector plenum, and a second open end coupled to said outer collector plenum.

13. The fuel-fired fluid heating apparatus of claim 1 wherein:

said fuel-fired fluid heating apparatus further comprises a transfer plenum disposed exteriorly of said tank,

said second pass section is defined by at least one straight second pass tube having an inlet end coupled to said central collector plenum and an outlet end coupled to said transfer plenum, and

said third pass section is defined by at least one straight third pass tube having an inlet end coupled to said transfer plenum and an outlet end coupled to said outer collector plenum.

14. The fuel-fired fluid heating apparatus of claim 13 wherein:

said at least one straight second pass tube is a plurality of straight second pass tubes circumferentially spaced around said first pass section, and

said at least one straight third pass tube is a plurality of straight third pass tubes circumferentially spaced around said plurality of straight second pass tubes.

15. A fuel-fired water heater comprising:

a tank for holding water to be heated;

a condensing type heat exchanger disposed within said tank and having:

a vertically extending flue having an upper inlet end and a lower outlet end,

a central collector plenum coupled to said lower outlet end of said flue,

an outer collector plenum horizontally circumscribing said central collector plenum,

a plurality of vertically extending inverted U-tubes horizontally spaced around said flue, each said inverted U-tube having a lower inlet end coupled to said central collector plenum, and a lower outlet end coupled to said outer collector plenum, and

an exhaust pipe having an inlet portion coupled to said outer collector plenum; and

a fuel burner having an outlet coupled to said upper inlet end of said flue, said fuel burner being operative to flow combustion gases through said flue and then the balance of said condensing type heat exchanger.

16. The fuel-fired water heater of claim 15 wherein:

said fuel-fired water heater is a commercial water heater.

17. The fuel-fired water heater of claim 15 wherein:

said inlet portion of said exhaust pipe is coupled to a lower side of said outer collector plenum, and

said fuel-fired water heater further comprises a condensate line disposed within said tank and interconnected between said inlet portion of said exhaust pipe and a bottom side portion of said central collector plenum.

18. The fuel-fired water heater of claim 15 wherein:

said outer collector plenum has a bottom side that slopes downwardly toward said inlet portion of said exhaust pipe, said bottom side having a lowermost portion to which said inlet portion of said exhaust pipe is coupled.

19. The fuel-fired water heater of claim 15 wherein:

a portion of said central collector plenum extends downwardly beyond said outer collector plenum.

20. The fuel-fired water heater of claim 19 wherein:

said portion of said central collector plenum has a downwardly domed configuration.

21. A fuel-fired water heater comprising:

a tank for holding water to be heated;

a transfer plenum disposed exteriorly of said tank at an upper end portion thereof;

a condensing type heat exchanger disposed within said tank and having:

a vertically extending flue having an upper inlet end and a lower outlet end,

a central collector plenum coupled to said lower outlet end of said flue,

an outer collector plenum horizontally circumscribing said central collector plenum,

a first plurality of vertical tubes horizontally spaced around said flue and having lower inlet ends coupled to said central collector plenum, and upper outlet ends coupled to said transfer plenum,

a second plurality of vertical tubes disposed horizontally outwardly of and horizontally spaced around said first plurality of vertical tubes, said second plurality of vertical tubes having upper inlet ends coupled to said transfer plenum, and lower outlet ends coupled to said outer collector plenum, and

an exhaust pipe having an inlet portion coupled to said outer collector plenum; and

a fuel burner having an outlet coupled to said upper inlet end of said flue, said fuel burner being operative to flow combustion gases through said flue and then the balance of said condensing type heat exchanger.

22. The fuel-fired water heater of claim 21 wherein:

said fuel-fired water heater is a commercial water heater.

23. The fuel-fired water heater of claim 21 wherein:

said inlet portion of said exhaust pipe is coupled to a lower side of said outer collector plenum, and

said fuel-fired water heater further comprises a condensate line disposed within said tank and interconnected between said inlet portion of said exhaust pipe and a bottom side portion of said central collector plenum.

24. The fuel-fired water heater of claim 21 wherein:

said outer collector plenum has a bottom side that slopes downwardly toward said inlet portion of said exhaust pipe, said bottom side having a lowermost portion to which said inlet portion of said exhaust pipe is coupled.

25. The fuel-fired water heater of claim 21 wherein:

a portion of said central collector plenum extends downwardly beyond said outer collector plenum.

26. The fuel-fired water heater of claim 25 wherein:

said portion of said central collector plenum has a downwardly domed configuration.

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