LOW EMISSION, WOOD FUELED HYDRONIC HEATER

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A wood burning hydronic heater comprises a primary firebox into which the wood is loaded and wherein initial combustion occurs. The heater also includes a secondary combustion chamber below the primary firebox into which the combustible gases from the primary firebox are forced and into which a fresh air stream is passed to burn the gases. A primary heat exchanger downstream of the secondary combustion chamber is adapted to reduce the temperature of the exhaust exiting from the secondary combustion chamber. A catalytic combustor, located in a chamber downstream of the secondary combustion chamber and primary heat exchanger, completes combustion and reduces emissions.
**LOW EMISSION, WOOD FUELED HYDRONCHEATER**

**CLAIM OF PRIORITY**


**FIELD OF THE INVENTION**

[0002] The present invention generally relates to wood fueled hydronic heaters and more particularly to a low emission, wood fueled hydronic heater incorporating a catalytic convertor.

**BACKGROUND OF THE INVENTION**

[0003] Wood burning furnaces, and particularly hydronic heaters (also called outdoor wood heaters or outdoor wood boilers), are increasingly being used in a multiple of residential and commercial applications. Specifically, wood burning hydronic heaters are used in place of natural gas, oil, propane, and other fossil fuel burning applications, particularly for furnaces that are used to heat water. Water is circulated through a heat exchanger in the furnace and piped to a nearby building, providing both heat and hot water to the building. The heat energy from the heated water is then transferred to the residential or commercial application through either a water-to-water heat exchanger or water-to-air heat exchanger. Such furnaces are often housed in a small shed provided with an exhaust vent. Most hydronic heaters are used in rural, cold climate areas, where wood is readily available, but can also be found throughout North America.

[0004] Given the emissions inherent in the burning of wood or wood-related products, such as wood pellets or, for example, corn, there is an increasing interest in decreasing smoke emissions, especially particulate emissions, while maintaining or improving the efficiency of the combustion process. However, the water jacket surrounding the fire tends to lower the temperature within the firebox, thus interfering with the ability to obtain a relative hot fire and improving the efficiency of the combustion process. The present disclosure presents an effort to decrease the smoke emissions of a wood burning hydronic heater without compromising efficiency or performance.

**SUMMARY OF THE INVENTION**

[0005] According to one aspect of the present invention, a wood burning hydronic heater includes a primary firebox into which the wood is loaded and where initial combustion occurs. A secondary burn or combustion chamber below the primary firebox is provided into which the combustible gases from the primary firebox are directed and into which an air stream is passed to additionally burn the smoke-filled gases at extreme temperatures to maintain high combustion efficiency. The heater further includes a primary heat exchanger to reduce the temperature of the hot exhaust from the extreme temperature in the secondary combustion chamber to a temperature suitable for use with a catalytic combustor. The catalytic combustor is located in a chamber between the primary heat exchanger and a secondary heat exchanger, burns particulate matter and improves the resulting combustion products. The heater finally includes a secondary heat exchanger that extracts heat from the exhaust gases such that the exiting stack temperature of exhaust gases is about 250° to 300° F.

[0006] Another aspect of the invention includes a method of reducing the smoke emissions of a wood burning hydronic heater that includes a primary firebox into which the wood is loaded and where initial combustion occurs. A secondary combustion chamber below the primary firebox is provided into which the combustible gases from the primary firebox are directed and into which an air stream is passed to burn the gases at extreme temperatures to maintain high combustion efficiency. The method further includes directing the combusted gases to a primary heat exchanger to reduce the temperature of the hot exhaust from the extreme temperature to a temperature suitable for use with a catalytic combustor. The gas is then directed to a catalytic combustor located in a chamber between the primary heat exchanger and a secondary heat exchanger for reducing particulate matter and improving the combustion process. The method finally includes directing the heated gas to a final heat exchanger that extracts heat from the exhaust such that the exiting stack temperature of exhaust gases is about 250° to 300° F.

[0007] These and other aspects, objects, and advantages of the present invention will be further understood and appreciated by those skilled in the art by reference to the following written specification, claims, and appended drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0008] In the drawings:

[0009] FIG. 1 is a schematic representation of the structure and method associated with the disclosed low emission, wood hydronic heater;

[0010] FIG. 2A is a front view of the low emission, wood hydronic heater;

[0011] FIG. 2B is a side view of the low emission, wood hydronic heater;

[0012] FIG. 3 is a perspective, exploded view of the heat shield and openable door of the low emission, wood hydronic heater;

[0013] FIG. 4 is a perspective view of the brick combustion plenum for delivering air into the low emission, wood hydronic heater;

[0014] FIG. 5 is another perspective view of the brick combustion plenum for delivering air into the low emission, wood hydronic heater;

[0015] FIG. 6 is yet another perspective view of the brick combustion plenum for delivering air into the low emission, wood hydronic heater, wherein several of the bricks have been removed for clarity;

[0016] FIG. 7 is still another perspective view of the brick combustion plenum for delivering air into the low emission, wood hydronic heater;

[0017] FIG. 8 is an additional perspective view of the brick combustion plenum for delivering air into the low emission, wood hydronic heater, wherein one of the bricks has been removed for clarity;

[0018] FIG. 9 is a perspective view of the horizontally slotted brick for directing air within the brick combustion plenum;

[0019] FIG. 10 is a perspective view of the vertically slotted brick within the brick combustion plenum having air channels to introduce air at a downward angle into the vertical channels in the brick for combustion in the secondary combustion chamber of the low emission, wood hydronic heater;
FIG. 11 is a perspective view of the primary firebox of the low emission, wood hydronic heater with the removable air channel removed;

FIG. 12 is a perspective view of the removable air channel of the low emission, wood hydronic heater;

FIG. 13 is a perspective view of the rear of the low emission, wood hydronic heater with the rear panel removed and the fan assembly removed from the fresh air inlet;

FIG. 14 is a perspective view of the fan assembly of the low emission, wood hydronic heater removed from the fresh air inlet;

FIG. 15 is a perspective view of the fresh air inlet of the low emission, wood hydronic heater with the fan assembly removed;

FIG. 16 is a side view of the chamber into which the catalytic combustor is placed;

FIG. 17 is a perspective view of the secondary heat exchanger;

FIG. 18 is a perspective view of the base of the low emission, wood hydronic heater;

FIG. 19 is a front view of the water level indicator of the low emission, wood hydronic heater in the full position; and

FIG. 20 is a front view of the water level indicator of the low emission, wood hydronic heater in the less than full position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

For purposes of description herein, the terms “upper,” “lower,” “right,” “left,” “rear,” “front,” “vertical,” “horizontal,” and derivatives thereof shall relate to the invention as oriented in FIG. 2A, with reference to a viewer facing the front of the furnace. However, it is to be understood that the invention may assume various alternative orientations and step sequences, except where expressly specified to the contrary. It is also to be understood that the specific parts, devices and processes illustrated in the attached drawings and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

Further, where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit unless the context clearly dictates otherwise, between the upper and lower limit of that range, and any other stated or intervening value in that stated range, is encompassed within the invention. The upper and lower limits of these smaller ranges may independently be included in the smaller ranges, and are also encompassed within the invention, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the invention.

Referring to the Figures, the reference numeral 100 generally designates a wood burning hydronic heater comprising several components, including: (1) a primary firebox 102; (2) a brick combustion plenum 104; (3) a secondary combustion chamber 106; (4) a primary heat exchanger 108; (5) a catalytic combustor 110; and (6) a secondary heat exchanger 112.

The primary firebox 102 is generally a brick or ceramic lined chamber formed within a steel compartment 114, as shown in FIG. 1. Wood is loaded through an opening 116 that may be accessed via an openable, fire-resistant door 118. After being loaded, the wood may be ignited. The door 118 preferably comprises an inner stainless steel door or heat shield 120 and an outer door 122, as shown in FIG. 3. The inner door 120 protects the user from blowback when the door is opened and protects the outer door 122 and non-water-jacketed door frame 124 from heat. The primary firebox 102 includes a brick combustion plenum 104 that forms a brick floor 126 and brick inclined side walls 128, where the plenum 104 is comprised of a plurality of slotted, refractory bricks intermixed therein with conventionally constructed refractory bricks. Thus, the wood fuel only sits on firebrick. This design minimizes corrosion of steel and increases burn temperatures, in part owing to the ability of refractory bricks to absorb and retain heat energy. A first set of horizontally slotted bricks 130 have a plurality of slots that form horizontal or transverse channels 132, as best shown in FIG. 9, and a second set of vertically slotted bricks 134 have a plurality of slots that cooperate to form vertical or downwardly-directed channels 136, as shown in FIG. 10. The second set of vertically slotted bricks 134 also has a plurality of downwardly inclined slots 138 in fluid communication with the vertical channels 136, as discussed further below and as also seen in FIG. 10.

The secondary combustion chamber 106 is disposed below the primary firebox 102 and plenum 104. The secondary combustion chamber 106 is fully brick-lined front to back within the secondary combustion chamber 106 to enable complete combustion of all remaining gases, as shown in FIGS. 4 & 5. The brick lining is fully insulated to protect the steel compartment 114 and still retain sufficient heat to maintain high combustion efficiency. Also, it is has been found that high temperature combustion is desirable. Smoke is essentially an unburned carbon. At temperatures above 1200°F, this carbon is consumed and no smoke is produced. Thus, temperatures reaching 2000°F in the secondary combustion chamber 106 are sought to enable the unit to burn at high temperatures and therefore operate very cleanly with no visible smoke produced.

Outside fresh air is delivered to the brick combustion plenum 104, which includes the channels 132 and 136 and slots 138 to form airflow paths 146, 148, 152, and 154, via two separate air delivery channels 140 and 142, as shown in FIG. 4, from an external fan assembly 156. Preferably, both channels 140 and 142 are relatively short enough to allow ready cleaning access. The first channel 140 forces the air up, where it is vented into an upper portion 144 of the otherwise sealed primary firebox 102. The second channel 142 forces air into a first of a pair of side airflow paths 146, 148 created on each side of the firebox 102 between the brick floor 126 and brick inclined side walls 128 and the insulating brick liner 150 of the steel compartment 114, as shown in FIG. 5. Horizontal airflow paths 152 formed by the horizontal channels 132 in the horizontally slotted bricks 130 allow air to flow to the opposite side of the firebox 102, as shown in FIGS. 6 and 7. Thus, fresh air is introduced to each of the pair of side airflow paths 146, 148.

Vertical or downwardly-directed airflow paths 154 in the vertically slotted bricks 134 provide fluid communication between the firebox 102 and secondary combustion chamber 106 below the firebox 102, as shown in FIG. 6. It is
to be noted that in the view of FIG. 6, several vertically slotted bricks 134 have been removed to provide a clearer view of the vertical channels 136. As air is forced into the upper portion 144 of the firebox 102, the smoke of the burning wood is forced into the vertical or downwardly-directed channels 136 and into the secondary combustion chamber 106 below. The vertically-oriented channels 136 in the brick preferably form four vertical or downwardly-directed airflow paths 154, each preferably 0.625 inches deep by 6.0 inches wide by 4.5 inches high (the height of standard firebrick). The four constricted channels 136 force highly combustible gases through the airflow paths 154 at high velocity, similar to a constricted burner tip on a propane torch. The downwardly inclined slots 138 likewise force fresh air into the downwardly-directed channels 136, and also act as nozzles to introduce and direct air at a downward angle, into the secondary combustion chamber 106, below the pyrolysis zone in the firebox 102 (or the area where combustible gases are created), as shown in FIG. 6.

[0037] The fan assembly 156 preferably comprises a blower 158, damper 160, and solenoid 162. The blower 158, damper 160, and solenoid 162 are preferably mounted together to create an easily movable fan assembly 156, as shown in FIG. 13 and 14, that may be preferably removed by detaching a clip (not shown) for ease of cleaning the inlet 224 and channels 140 and 142, as shown in FIG. 15. Solenoid 162 is attached to the damper 160 that seals shut against an air opening 161 that provides air to the primary firebox 102 when the blower 158 is deactivated. Preferably, the solenoid 162 is mounted away from the airflow to prevent smoke backflow and protect the blower 158.

[0038] Preferably, a removable firebox air channel 163 is mounted to a rear wall 149 of the primary firebox 102 by a pair of brackets 151, 153. The air channel 163 preferably comprises a flat rectangular steel stamping formed into an open box measuring about 3 inches wide and 2 inches deep having a closed bottom end 165 and an upper end 167, at an exit opening 169 and tab 171 is situated. The lower bracket 151 is located just below the air opening 161 and is shaped to snugly accept the closed bottom end 165 of the air channel, as shown in FIG. 11. Similarly, the upper bracket 153 is situated above the air opening 161 and is shaped to snugly accept the tab 171. Air may thus be introduced into the primary firebox 102 via the fan assembly 165 into the rear of the primary firebox 102 through the air opening 161 in the lower rear wall 149, upwards through the air channel 163 and out the exit opening 169 into upper portion of the primary firebox 102.

[0039] The removable firebox air channel 163 is particularly useful where unseasoned wood is used or in warmer weather when the unit tends to cycle off more frequently, where creosote can accumulate in this channel and restrict airflow. The results of such accumulations are reduced combustion, more creosote, and in some cases failure. As noted above, the air channel 163 is preferably located at the rear and inside the primary firebox 102. To remove it, the user may reach through the door 118 into the primary firebox 102 after it has cooled and simply lift the removable firebox air channel 163 from the brackets 151, 153. With a rear air channel 161 removed, the user can clean and replace the rear air channel 161 quite easily, particularly since no brick needs to be removed in this process.

[0040] It has been found that moving the air through the brick as described herein, not above or below the brick, creates optimal conditions for gasification of the smoke entering the secondary combustion chamber 106. That is, as the combustible gases laden with smoke pass from the primary firebox 102 to the secondary combustion chamber 106, fresh air is introduced into the gases as these gases pass through the brick, which greatly enhances combustion of the smoke upon entering the secondary combustion chamber 106 and the amount of heat energy that is harvested from the wood. Since these passages are constricted, the gases are forced to pass through the vertical channels 136 at relatively high velocity for increased combustion and efficiency. Moreover, air is introduced into the firebox 102 through dual channels, which provide optimal air supply both up into firebox 102 and into the in-brick air channels as described herein.

[0041] A sealed steel reservoir 166 is situated around the primary firebox 102. A cavity or water jacket 168 is formed between the two compartments 114 and 166 and is filled with water that is preferably constantly circulated between the furnace and the building. The heated water delivered to the building is then passed through a radiator or heat exchanger, such as in the path of a forced air generator, where the heat is extracted from the water and distributed through the building to be warmed. Ideally, the water exiting the heater 100 is at 180°F and the temperature returning to the heater from the building is 160°F. The water jacket 168 is open to the atmosphere and provided with a water level indicator 170, as shown in FIG. 1 and FIGS. 19 and 20. The water level indicator 170 is fitted to the water level indicator fitting 172 on the top of the heater 100 and comprises a support 174, float 176, indicator 178, and indicator scale 180. An orifice 218 at the bottom of the support 174 and an orifice 220 at the top of the support 174 receive a metal rod 222. The float 176 is attached to a lower end of the rod 222 and the indicator 178 is formed at the upper of the rod 222 and is adjacent the indicator scale 180 so that the water level may be conveniently determined. As the water level in the water jacket 168 drops, the float 176 and indicator 178 will drop as well, as shown in FIG. 20. If the water level is deemed to be low, a tap (not shown) can be opened to provide additional water to the water jacket 168 as necessary, which will in turn raise the float 176 and indicator 178 relative to the indicator scale 180 to the "FULL" location, as shown in FIG. 19.

[0042] The fan assembly 156 is situated to provide additional air flow to the furnace and is provided with a thermocouple that measures the temperature of the water leaving the water jacket 168. The fan assembly 156 is activated whenever this temperature drops below 160°F, thus stoking the ignited wood in the primary firebox 102 and forcing air into the brick combustion plenum 104 to further combat the smoke passing from the primary firebox 102 through the vertical channels 136 and into the secondary combustion chamber 106 to release more thermal energy to the water jacket. When the temperature returns to 180°F, the fan assembly 156 is deactivated and the fire is allowed to return to a smoldering level. This cycle repeats to maintain the temperature of the water delivered to the building. Wood is added at regular intervals once or twice a day to maintain the delivery of heated water to the building.

[0043] The exhaust gas is then forced into the primary heat exchanger 108 situated at the rear and above the secondary combustion chamber 106 and adjacent the primary firebox 102. The primary heat exchanger 108 preferably comprises a set of nine tubes 184, each having a diameter of 1.6 inches, disposed in the water jacket 168, as shown in FIG. 1. The
purpose of the primary heat exchanger 108 is to reduce the temperature of the hot exhaust from about 2000°F. to around 600°F.

[0044] Further, the presently disclosed hydronic heater is capable of being fitted with a catalytic combuster 110 for emissions control. Thus, after passing through primary heat exchanger 108, the exhaust gas is passed to a catalytic combuster 110. The catalytic combuster 110 is located in a chamber 188 situated between the primary heat exchanger 108 and secondary heat exchanger 112, as shown in FIGS. 1 and 16. The catalytic combuster 110 reduces the concentration of invisible particulate matter and significantly improves the combustion process. However, the catalytic combuster 110, constructed from materials such as platinum or palladium, requires a minimum temperature of 400°F. to function properly, but will be destroyed if operated at temperatures above 1600°F. Generally, exhaust exiting the primary heat exchanger 108 and entering the catalytic combuster 110 at 600°F. will exit at 800°F., since the catalytic process generates heat.

[0045] Since the catalytic combuster 110 is situated downstream of the primary heat exchanger 108, the temperatures of the relatively cool exhaust gas allow use of a catalytic combuster, which has not been known to have been used in a hydronic heater prior to the presently disclosed hydronic heater. As shown in FIG. 16, the catalytic combuster chamber 188 includes deflector 190, cover 192, and sides 194, as well as a holder 196 on the air deflector 190 that holds the catalyst disk 198 at an angle that maximizes air flow through the catalytic combuster 110. This structure also protects the surrounding steel by directing the flow of hot exhaust gases away from non-water-jacketed steel. Since the device is preferably made of stainless steel, this is advantageous. Also, the shown structure allows the catalyst disk 198 to be easily removed for cleaning or replacement.

[0046] The exhaust gas is finally passed through the secondary heat exchanger 112 that extracts heat from the exhaust such that the exiting stack temperature of the exhaust gases is around 250°F. to 300°F. This improves efficiency tremendously. The secondary heat exchanger 112 preferably comprises a set of eight U-shaped tubes 202, best seen in FIG. 17, also disposed in the water jacket 168, as shown in FIGS. 1 and 2. Each of the tubes 202 has an inlet 204 and an outlet 206 from which the exhaust gas exits the secondary heat exchanger 112 and enters the stack 208 and is vented to the atmosphere.

[0047] The disclosed hydronic heater enjoys several advantages. It employs a compact design owing to the unique flow patterns of the exhaust gas within. An inverted burning process is used, which passes combustible gases downward through the wood coals. Air is fed into the firebox 102 through dual airflow paths 146, 148, as shown in FIG. 6. Upward flowing air is pushed up an upper region 144 of the primary firebox chamber 102 to create rolling combustion that then must go down. Combustion within the secondary combustion chamber 106 is also directed from the front to the back of the secondary combustion chamber 106. Gases then move upward through the primary heat exchanger tubes 184 creating a bottom to top flow of combustion gases after the secondary combustion chamber 106. The result is a reduction in creosol build-up and back-draft into the fan assembly 156, which increases the durability of the blower 158, particularly in combination with the fan assembly damper 160 that is actuated by the solenoid 162 to the closed position when the blower 158 is deactivated. The unique construction of the disclosed hydronic heater allows the emissions to reach 0.14 pounds particulate per 1,000,000 BTU output, which is less than the target of 0.32 pounds particulate per 1,000,000 BTU output established by the U.S. Environmental Protection Agency’s Phase 2 Hydronic Heater Voluntary Partnership Program.

[0048] The construction methods for the presently disclosed hydronic heater 100 includes mainly cast bricks, bolted assemblies, and bent tube heat exchangers. For example, the heat exchangers 108 and 112 (see FIG. 1) are simply bent tubes to transfer heat from the gases to the water. The primary subassemblies of the presently disclosed hydronic heater include a front panel 210, bent tubes 202, vertical tubes 184, refractory brick frame 212, water jacket 168, and base assembly 214, as shown in FIGS. 2A and 2B. This allow for ease of construction, cost-containment, and manufacturing repeatability. Bolts are preferably used to attach the lower base assembly 214 to the upper water jacket assembly 168, as shown in FIGS. 2A and 2B. Silicone caulk is preferably used as a sealant. The bolted-together components are those that are not required to be watertight. Bolted-together components also reduce welding and fabrication costs and enable “modularity” or the ability to replace components in the future should a component wear out. Finally, the presently disclosed hydronic heater 100 employs a pallet base design, as shown in FIG. 18, has perpendicularly oriented forklift access receivers 216, which makes lifting the hydronic heater 100 possible with a standard pallet jack or forklift. Preferably, the presently disclosed hydronic heater 100 may be lifted from at least three sides to facilitate shipping.

[0049] It is to be understood that variations and modifications can be made on the aforementioned structure without departing from the concepts of the present invention, and further it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise. As discussed herein, the embodiments of the present invention include, but are not limited to, any combination or sub-combination of elements or steps or portions of steps described herein and the various claims presented herein.

We claim:

1. A wood burning hydronic heater comprising:
   a primary firebox into which the wood is loaded and wherein initial combustion occurs;
   a secondary combustion chamber into which the combustible gases from the primary firebox are directed and into which an air stream is passed to burn the gases;
   a primary heat exchanger downstream of the secondary combustion chamber adapted to reduce the temperature of the exhaust exiting from the secondary combustion chamber; and
   a catalytic combuster located in a chamber downstream of the secondary combustion chamber.

2. The heater of claim 1 further comprising a secondary heat exchanger that extracts heat from the exhaust gases such that the exiting stack temperature of exhaust gases is about 250°F. to 300°F.

3. The heater of claim 2, wherein the catalytic combuster is located in a chamber between the primary heat exchanger and a secondary heat exchanger.

4. A wood burning hydronic heater comprising:
a primary firebox into which the wood is loaded and wherein initial combustion occurs;
a secondary combustion chamber below the primary firebox into which the combustible gases from the primary firebox are directed;
vertical channels providing fluid communication between the firebox and the secondary combustion chamber below the firebox;
an air blower; and
a brick combustion plenum disposed between the primary firebox and secondary combustion chamber, the brick combustion plenum having an upper channel and a lower channel, wherein the upper channel forces air into an upper portion of the primary firebox and the lower channel forces air into the vertical channels.

5. The heater of claim 4 further comprising downwardly inclined slots that pass air from the lower channel to the vertical channels.

6. The heater of claim 5, wherein the downwardly inclined slots act as nozzles to introduce air at a downward angle for combustion in the secondary burn combustion.

7. The heater of claim 5, wherein there are four vertical channels.

8. The heater of claim 5 further comprising a pair of side airflow paths on each side of the firebox in fluid communication with the lower channel to pass air to each side of the firebox.

9. The heater of claim 5, wherein the primary firebox has a floor constructed of arranged bricks, the vertical channel formed in a brick forming the floor of the primary firebox.

10. The heater of claim 9, wherein the bricks further comprise the downwardly inclined slots formed in each that pass air from the lower channel to the vertical channels.

11. The heater of claim 4, wherein one of the bricks between the primary firebox and the secondary combustion chamber has a horizontal channel forming a horizontal airflow path with the lower channel.

12. The heater of claim 4, wherein the primary firebox has a floor constructed of arranged bricks, and one of the arranged bricks has a horizontal channel extending along the length of the one of the arranged bricks to provide for fluid communication with the lower channel to allow air to flow to each side of the firebox.

13. The heater of claim 1, wherein the emissions from the heater is less than 0.32 pounds particulate per 1,000,000 BTU output.

14. A wood burning hydronic heater comprising:
a primary firebox into which the wood is loaded and wherein initial combustion occurs;
a secondary combustion chamber into which the combustible gases from the primary firebox are directed and into which an air stream is passed to burn the gases;
a primary heat exchanger downstream of the secondary combustion chamber adapted to reduce the temperature of the exhaust exiting from the secondary combustion chamber;
a catalytic combustor located in a chamber downstream of the primary heat exchanger; and
a secondary heat exchanger located downstream of the catalytic combustor that extracts heat from the exhaust gases such that the exiting stack temperature of exhaust gases is about 250° to 300° F.

15. The heater of claim 14 further comprising an air blower in fluid communication with the primary firebox through an air opening in a rear wall of the primary firebox and a removable firebox air channel mounted to the rear wall of the primary firebox by a pair of brackets, whereby air is introduced into the primary firebox via the air blower into the rear of the primary firebox through the air opening in the rear wall, upwards through the air channel and out the exit opening into upper portion of the primary firebox.

16. The heater of claim 15, wherein the air channel comprises a flat rectangular steel stamping formed into an open box having a closed bottom end and an upper end, and an exit opening and tab disposed at the upper end; and wherein one of the pair of brackets is located just below the air opening and is shaped so as to snugly accept the closed bottom end of the air channel and the other one of the pair of brackets is situated above the air opening and is shaped so as to snugly accept the tab.

17. A method of reducing the smoke emissions of a wood burning hydronic heater, the method comprising the steps of:
providing a primary firebox into which the wood is loaded and wherein initial combustion occurs;
providing a secondary combustion chamber into which the combustible gases from the primary firebox are directed, during which an air stream is passed to burn the gases at extreme temperatures to maintain high combustion efficiency;
directing the combusted gases to a primary heat exchanger to reduce the temperature of the exhaust to a temperature suitable for use with catalytic combustion; and
directing the exhaust gas to a catalytic combustor located in a chamber downstream of the primary heat exchanger.

18. The method of claim 17 further comprising the steps of:
providing a secondary heat exchanger that extracts heat from the exhaust gases such that the exiting stack temperature of exhaust gases is about 250° to 300° F.

19. The method of claim 18, wherein the catalytic combustor is located in a chamber between the primary heat exchanger and a secondary heat exchanger.

20. The method of claim 19, wherein the emissions from the heater is less than 0.32 pounds particulate per 1,000,000 BTU output.