Title: FIREPLACE WITH EXHAUST HEAT EXCHANGER

Abstract: A heat exchanger system and method for transferring heat from exhaust air from a fireplace to air to be delivered to a living space is described. Heated exhaust air is passed through a heat exchanger before exhaustion from the structure. The heat exchanger couples the exhaust duct and the intake duct and transfers otherwise unused heat from the waste products to the outside air to increase the overall efficiency of the heated product source.
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FIREPLACE WITH EXHAUST HEAT EXCHANGER

BACKGROUND

[0001] The present invention generally relates to fireplaces, and more specifically fireplaces equipped with one or more heat exchangers for transferring heat from the fireplace exhaust air to air to be delivered to a living space.

[0002] In combustion fireplaces, such as gas or biomass burning fireplaces, hot exhaust air produced during combustion exits the fireplace at a relatively higher temperature than its surroundings, carrying with it some potentially useful thermal energy. This results in less than optimal fireplace efficiency.

SUMMARY

[0003] Some embodiments relate to a heat exchange system including a firebox, a combustion element, a plenum, and at least one heat exchanger. The firebox includes a plurality of panels combining to define a combustion chamber. The combustion chamber includes a combustion air inlet port in fluid communication with a source of combustion air and an exhaust air outlet port. The combustion element is disposed within the combustion chamber. The plenum defines an air intake end and an air output end and includes a plurality of walls defining an air pathway between the air intake and air output ends. The heat exchanger includes a housing having an outer surface disposed within the plenum. The housing includes a first end coupled to the exhaust air outlet port of the combustion chamber and a second end. Additionally, the heat exchanger includes a plurality of baffle plates within the housing. The baffle plates define at least one internal pathway within the housing. The internal pathway extends through a plurality of 180 degree turns from the first end to the second end of the heat exchanger. Additionally, an outer surface of the heat exchanger may include a plurality of heat transfer assist structures such as air foils, pins, ridges, fins, and the like.
In some embodiment, the heat exchange system includes a second heat exchanger coupled to and in fluid communication with the first heat exchanger. Like the first heat exchanger, the second heat exchanger also includes a housing having an outer surface disposed within the plenum. The housing includes a first end coupled to the exhaust air outlet port of the combustion chamber and a second end. Additionally, the heat exchanger includes a plurality of baffle plates within the housing. The baffle plates define at least one internal pathway within the housing. The internal pathway extends through a plurality of 180 degree turns from the first end to the second end of the second heat exchanger.

Other embodiments relate to a fireplace heat exchange system located within a building structure defining a living space. The fireplace heat exchange system includes a plenum, a firebox, a combustion element, and at least one heat exchanger. The plenum defines an air intake end and an air output end and includes a plurality of walls defining an air pathway between the air intake and air output ends. The firebox is located within the plenum. The firebox includes a plurality of panels that define a combustion chamber. The combustion chamber includes at least one combustion air inlet port in fluid communication with a combustion air source and an exhaust air outlet port. A combustion element adapted to generate heat and exhaust products via combustion of a fuel source with combustion air received through the combustion air inlet port is disposed within the combustion chamber. Additionally, a heat exchanger is mounted to the firebox located within the plenum. The heat exchanger includes a housing having a first end coupled to the exhaust air outlet port of the combustion chamber and a second end. Additionally, the heat exchanger includes a plurality of baffle plates within the housing. The baffle plates define at least one internal pathway within the housing. The internal pathway extends through a plurality of 180 degree turns from the first end to the second end of the heat exchanger.

Still other embodiments relate to a method of transferring heat from heated exhaust air to air to be delivered to a living space. The method
includes passing relative hot exhaust air from a combustion chamber into a first heat exchanger located within a plenum. The plenum includes a plurality of walls defining an air pathway between an air intake end and an air output end. The heat exchanger includes a housing, an exhaust air inlet and an exhaust air outlet. The housing has an outer surface and a plurality of baffle plates. The plurality of baffle plates defines at least a first internal pathway within the housing. The first internal pathway extends through a plurality of 180 degree turns from the exhaust air inlet to the exhaust air outlet of the heat changer. The method also optionally includes passing air through the plenum along the air pathway defined between the air intake and air output ends and contacting the air with the outer surface of the heat exchanger housing. Additionally, the method includes transferring heat from the relatively hot exhaust air passing through the heat exchanger to the air passing through the plenum.

While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0008] FIG. 1 is a side schematic view of a heat exchange system according to some embodiments.

[0009] FIG. 2 is a side schematic view of a heat exchange system according to some embodiments.

[0010] FIG. 3A is a side schematic view of a heat exchange system according to some embodiments.

[0011] FIG. 3B is another side schematic view of a heat exchange system according to some embodiments.

[0012] FIG. 4 is a front schematic view of a heat exchange system according to some embodiments.
FIG. 5 is a cross-sectional view of a heat exchanger for use in a heat exchange system provided according to some embodiments.

FIG. 6 is a cross-sectional view of a heat exchanger for use in a heat exchange system provided according to some embodiments.

FIG. 7 is a cross-sectional view of a heat exchanger for use in a heat exchange system according to some embodiments.

While the invention is amenable to various modifications and alternative forms, various embodiments have been shown by way of example in the drawings and are described in detail below. The intention, however, is not to limit the invention to the particular embodiments described. On the contrary, the invention is intended to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

FIGS. 1-3B are side schematic views of a fireplace heat exchange system 10 according to various embodiments of the present invention. FIG. 4 is a front schematic view of a fireplace heat exchange system 10 according to another embodiment of the present invention. The fireplace heat exchange system 10 can be used to extract heat from heated exhaust air produced by the combustion of a variety of fuel sources with air including gas, wood, pellets, corn, biomass, and the like. The heat exchange system 10 is located within a structure, for example within a wall space of a residential, commercial, or industrial building.

Referring to FIGS. 1-4, the heat exchange system 10 includes a firebox 14, a burner system 26, and a heat exchanger 40. The firebox 14 has a plurality of panels 18 combined to define a combustion chamber 22. In some embodiments, the panels 18 of the firebox 14 include two opposing side panels (not shown), top and bottom panels, and a rear panel. As shown in FIGS. 1-3B, the firebox 14 also includes at least one panel 20 that allows a user to access the combustion chamber 22. The front of the firebox 14 optionally includes glass doors or a sealed glass panel. In some embodiments, the firebox 14 is of a type employed with one or more of the
following heat generating devices: a wood burning fireplace; a gas fireplace (including fireplaces that include a gas-start mechanism); a wood burning stove; a corn burning stove; a pellet stove; a wood furnace; or other heat generating devices.

[0019] The firebox 14 can be made from a variety of suitable materials capable of withstanding the high temperatures. In some embodiments, the firebox 14 is formed of a compression molded material including an inorganic fiber and a binder, such as the compression molded materials described in U.S. Patent 7,098,269, entitled "Compression Molded Inorganic Fiber Articles, and Methods and Compositions Used in Molding Same," which is incorporated herein by reference in its entirety, although a variety of firebox materials are contemplated.

[0020] The burner system 26 is located in the combustion chamber 22 and is adapted to generate heat and exhaust products via combustion of a fuel source with combustion air. The burner system 26 is adapted for use with one or more of a variety of fuel sources, such as wood, gas, pellets, corn, and biomass, among others, although in some embodiments the burner system 26 is used to combust natural gas. Depending on the type of fuel, the burner system 26 includes regulator valves, fuel feed lines, igniter mechanisms, nozzles, and/or other elements, for example, generally associated with a burner system. An exemplary gas burner system is shown and described in U.S. Patent 6,048,195, entitled "Hollow Ceramic Fiber Burner-log Element," which is incorporated herein by reference in its entirety.

[0021] In some embodiments, the combustion chamber 22 includes at least one combustion air inlet port in fluid communication with a source of combustion air and an exhaust air outlet port 36. Combustion air is optionally drawn from the living space, such air being referred to as room air. Combustion air can also be drawn into the combustion chamber 22 from outside of the structure in which the heat exchange system 10 is located, also described as outside air. In some embodiments, the combustion chamber 22 includes more than one combustion air inlet port with combustion air including a combination of room air and outside air. In some
embodiments, faux logs, embers, or other accessories are placed in the combustion chamber 22 to help simulate a wood fire.

[0022] The heat exchanger 40 is coupled to and in fluid communication with the exhaust air outlet port 36 provided in the combustion chamber 22. The heat exchanger 40 includes a housing 44 defining a first end 48 and a second end 52 and includes a plurality of baffle plates 80 defining at least one internal pathway within the housing 44 (described in further detail below). The heat exchanger 40 defines a substantially closed pathway through which exhaust air travels from the combustion chamber 22 to the outside.

[0023] The heat exchanger 40 is optionally adapted to work with any of a variety of heat generating devices, such as a gas fireplace or pellet stove, for example. According to some embodiments, the heat exchanger 40 maintains a low profile when coupled to the firebox 14, for example by substantially tracking or otherwise complementing the profile of the firebox 14, in order to minimize an overall height and/or head space of the heat exchange system 10. In some embodiments, the heat exchanger 40 is adapted to work with a heat generating device having an energy output ranging from about 15,000 to about 60,000 BTU, from about 30,000 to about 40,000 BTU, for example, as well as other energy outputs.

[0024] The heat exchanger 40 is made from a high heat conductivity, corrosion-resistant material, according to some embodiments. Exemplary materials include: sheet metal, stainless steel, coated stainless steel, aluminum, aluminum alloys, and ceramics, for example, as well as other suitable materials. In some embodiments, the outer surface 50 of the heat exchanger housing 44 may be smooth. In other embodiments, the outer surface 50 of the heat exchanger housing 44 includes a plurality of heat transfer assist structures 46 such as air foils, pins, ridges, fins configured to increase heat transfer, for example by increasing the surface area of the outer surface 50. For example, FIG. 3A schematically shows heat transfer assist structures 46 including a plurality of undulations or ridges whereas
FIG. 3B shows heat transfer assist structures 46 including a plurality of pins or fins.

[0025] The first end 48 of the heat exchanger housing 44 is coupled to and in fluid communication with the exhaust air outlet port 36 located in the combustion chamber 22. The second end 52 is in fluid communication with the outside of the structure or other appropriate exhaust location to serve as an exhaust port. Heated exhaust air, including any waste products produced during the combustion process, flows from the combustion chamber 22 via the exhaust air outlet port 36 and into the heat exchanger 40. The heated exhaust air flows through the heat exchanger 40 along the internal pathway defined by the baffle plates 80, and is ultimately vented outside via the exhaust port.

[0026] The exhaust air entering the first end 48 of the heat exchanger 40 has a higher temperature than the exhaust air exiting the heat exchanger 40 via the second end 52 which serves as the exhaust port. Typically, the temperature of the heated exhaust air entering the first end 48 of the heat exchanger 40 ranges from about 650°F to about 850°F. In contrast, the temperature of the exhaust air leaving the heat exchanger 40 via the second end 52 ranges from about 120°F to about 180°F. According to one embodiment, the heat exchanger 40 is configured such that at least a portion of the exhaust air condenses before being disposed to the outside such that the exhaust air temperature is lowered to a level permitting the use of PVC piping or other ducting material at the exhaust port. For example, the temperature of the air exiting the heat exchanger 40 has a temperature ranging from about 120°F to about 180°F. The condensate from the exhaust air is optionally collected in a condensate trap located at the lowest point of the heat exchanger 40. In some embodiments, the condensate trap includes a drain and a seal for draining the condensate from the heat exchanger 40. Alternately, a pan such as a drip pan, or a reservoir, is used for collecting the condensate.

[0027] As shown in FIGS. 1-2, the first end 48 of the heat exchanger housing 44 is optionally coupled to the exhaust air outlet port 36 of the
combustion chamber 22 such that the heat exchanger is spaced a distance from the outer surface 53 of the firebox 14. Air flow is permitted between the outer surface 53 of the firebox 14 and the outer surface 50 of the heat exchanger housing 44.

[0028] As shown in FIGS. 3A and 3B, the first end of the heat exchanger 40 is optionally coupled to the exhaust air outlet port 36 of the combustion chamber 22 such that the heat exchanger 40 is mounted flush with the outer surface 53 of the firebox 14 such that no space exists between the outer surface 53 of the firebox 14 and the outer surface 50 of the heat exchanger housing 44. In some embodiments, the heat exchanger housing 44 shares a common panel with the firebox 14.

[0029] As shown in FIGS. 2-3B, the heat exchanger 40 optionally includes a first portion 54 in fluid communication with a second portion 56. Exhaust air generally flows freely between the first and second portions 54 and 56 of the generally L-shaped heat exchanger 40. The first portion 54 is angularly offset from the second portion 56 such that the heat exchanger 40 is adapted to fit over the top and rear panels 18 of the firebox 14. In some embodiments, the first portion 54 is substantially orthogonal to the second portion 56 such that the overall shape of the heat exchanger 40 approaches and L-shape, although a variety of angular offsets are contemplated, including 45 degree angular offsets, for example. In some embodiments, the first portion 54 is angularly offset from the second portion 56 by at least 90 degrees.

[0030] In some embodiments, the heat exchanger system 10 includes a plurality of heat exchangers. For example, as shown in FIG. 2, heat exchanger system 10 includes heat exchangers 40a and 40b which are coupled to one another in a generally stacked configuration. The first end 48a of heat exchanger 40a is coupled to and in fluid communication with the exhaust air outlet port 36 of the combustion chamber 22. Exhaust air flows from the combustion chamber 22 and into the first heat exchanger 40a via the exhaust air outlet port 36. The exhaust air flows from the first end 48a to the second end 52a of the first heat exchanger 40a. Rather than being
exhausted to the outside, the exhaust air from the combustion chamber 22 flows out of the second end 52a of the first heat exchanger 40a and into the second heat exchanger 40b coupled thereto. The exhaust air then flows along the internal pathway defined within the second heat exchanger 40b from the first end 48b of the second heat exchanger 40b to the second end 52b, where it is then vented to the outside.

[0031] In some embodiments, the first heat exchanger 40a is coupled to the second heat exchanger 40b in a generally stacked configuration such that space exists between the outer surface 50a of the first heat exchanger 40a and the outer surface 50b of the second heat exchanger 40b such that airflow between the outer surfaces 50a, 50b of the two heat exchangers 40a, 40b is permitted. The coupled heat exchangers 40a, 40b are optionally mounted to the firebox 14 such that a space exists between the outer surface 50a of the first heat exchanger 40a and the outer surface 53 of the firebox 14, for example to allow airflow therebetween.

[0032] The coupled heat exchangers 40a, 40b may be mounted flush to the outer surface 53 of the firebox 14, such that no space exists between the outer surface 50a of the first heat exchanger 40a and the firebox 14, for example to enhance heat transfer between the firebox 14 and the heat exchanger(s) 40a, 40b. In still other embodiments, the first heat exchanger 40a is mounted to the firebox 14 such that the heat exchanger housing 44 of the first heat exchanger 40a and the firebox 14 share a common panel. Similarly, the second heat exchanger 40b may be coupled to the first heat exchanger 40a such that the outer surface 50a of the first heat exchanger 40a is flush with the outer surface 50b of the second heat exchanger 40b and/or the second heat exchanger 40b may be coupled to the first heat exchanger 40a such that the first and second heat exchanger housings 44 share a common wall.

[0033] According to some embodiments, the first heat exchanger 40a is coupled to the second heat exchanger 40b in a side by side configuration where exhaust air flows from the first heat exchanger 40a to the second heat
exchanger 40b via an air duct or other fluid communication means extending between them.

[0034] The flow of heated exhaust air out of the combustion chamber 22, through the heat exchanger 40, and to the outside may be assisted by an air assist device 58 located within the combustion chamber 22. The air assist device 58 creates a positive pressure environment within the combustion chamber 22 pushing the heated exhaust air from the chamber 22 into and through the heat exchanger 40 until the exhaust air is vented to the outside. Exemplary air assist devices include, but are not limited to, fans, blowers, and others.

[0035] As shown in FIGS. 1-3B, the heat exchanger 40 and combustion chamber 22 are optionally disposed within a plenum 62. The plenum 62 generally includes a plurality of walls defining an air pathway 66 extending between an air intake end 70 and an air output end 74. In some embodiments, the air intake end 70 is in fluid communication with a source of room air. In some embodiments, the air intake end 70 is in fluid communication with a source of outside air. If desired, the air flowing through the plenum 62 from the air intake end 70 to the air output end 74 is a combination of room air and outside air.

[0036] Air travels through the plenum 62 from the air intake end 70 to the air output end 74 and flows over an outer surface 50 of the heat exchanger housing 44. As a result, the air traveling along the pathway 66 defined by the plenum 62 becomes heated via a heat exchange process with the heated exhaust air flowing through the heat exchanger 40. In some embodiments, relatively cool outside air is used as the source of air to be heated, where the outside air becomes superheated and a portion of the exhaust air condenses, increasing the overall efficiency of the heat exchange process. Once the air is heated, it is returned to the living space and the relatively cooler exhaust air is exhausted outside via the second end 52.

[0037] As shown in FIG. 4, in some embodiments heat exchanger 40 is disposed within a plenum 62 provided separately and at a distance from
the firebox 14. This configuration facilitates remote location of the heat exchanger 40 and plenum 62 from the heat generating device that includes the combustion chamber 22. In some embodiments, the combustion chamber 22 of the heat generating device is fluidly connected to the heat exchanger 40 via one or more air ducts. Additionally, one or more blowers, fans, dampers, defectors, plenums, and the like may be added to the heat exchange system 10 to assist in the flow of heated exhaust air from the combustion chamber 22 to the heat exchanger 40 located within the plenum 62. In some embodiments, retrofitting the heat exchanger 40 and plenum 62 to a pre-existing heat generating device to form heat exchange system 10 is simplified by providing heat exchanger 40 in a plenum 62 that is separate and remote from the firebox 14. The heat exchanger 40 disposed within the plenum 62 can also be adapted to work with an existing heat generating device including an existing heat exchanger.

According to some embodiments, the flow of air to be heated through the plenum 62 is assisted by one or more air assist devices 64 located within the plenum 62. The air assist device 64 can be used to push or draw the air from the air intake end to the air output end 74 over the heat exchanger 40 and then to return the heated air to the room or structure. Exemplary air assist devices include, but are not limited to, fans, blowers, and the like.

FIGS. 5-7 are cross-sectional views of various embodiments of the heat exchanger 40 including one or more internal pathways 84 for exhaust air flow. As briefly described above, the heat exchanger 40 optionally includes a plurality of baffle plates 80 that define one or more internal pathways 84 for exhaust air flow through the heat exchanger 40 to the outside via the second end 52. In general, the overall effective length of the internal pathway 84 defined by the baffle plates 80 is longer than the length, width, or height of the heat exchanger housing 44.

The baffle plates 80 generally slow the flow of heated exhaust air through the heat exchanger 40, increasing the residence time of the heated exhaust air within the heat exchanger 40. In general terms, the
longer the heated exhaust air resides within the heat exchanger 40, the more efficient the heat exchange process will be with the air flowing over its outer surface 50. As described above with reference to FIGS. 3A and 3B, the outer surface 50 of the heat exchanger 40 may include a plurality of heat transfer assist structures 46 configured to maximize the surface area over which the heat exchange process occurs.

[0041] The various embodiments heat exchangers 40 are each optionally disposed within the plenum 62 such that the air flowing through the heat exchanger 40 is generally parallel or counter to the air flowing from the air intake end 70 to the air output end 74 of the plenum 62. The 180 degree turns created by the baffle plates 80 result in the addition of a cross flow component between the exhaust air flowing through the internal pathways 90, 92 within the heat exchanger 40 and the air to be heated flowing over the outer surface 50 of the heat exchanger housing 44.

[0042] If more than one heat exchanger 40 is used, the heat exchangers need not have the same internal pathway configuration defined by the baffle plates 80. Additionally, one heat exchanger 40 may be oriented within the plenum 62 such that the exhaust air flowing through the heat exchanger 40 is generally parallel to the air to be heated flowing through the plenum 62. An additional heat exchanger 40b may be coupled to a first heat exchanger 40a such that the exhaust air flow through the second heat exchanger 40b is counter to the air flow through the plenum 62 and the first heat exchanger 40a. In some embodiments, the opposite configuration is used in which the exhaust air flows through the first heat exchanger 40a is counter to the air flowing through the plenum 62 and the exhaust air flow through the second heat exchanger 40b is generally parallel to or in the same direction as the air flowing through the plenum 62.

[0043] As shown in FIG. 5, in some embodiments the baffle plates 80 define at least one internal pathway 84 extending from the first end 48 to the second end 52 of the heat exchanger 40. The internal pathway 84 can define a serpentine or tortuous path for the exhaust air such that exhaust air flows in a single general direction from the first end 48 to the second end 52.
of the heat exchanger 40 along an internal pathway 84 extending through a plurality of 180 degree turns. As shown in FIG. 5, the heat exchanger 40 facilitates the use of cross-flow (perpendicular to F) and parallel flow (in the same direction as F) modes of heat exchange. In other embodiments, the general direction of air flow is opposite to that of the exhaust air flow through the plenum such that the heat exchanger 40 exchanges heat via cross-flow and counter flow (flow in an opposite direction to F) modes of heat exchange.

[0044] FIG. 6 shows another configuration for heat exchanger 40 according to some embodiments where the heat exchanger 40 defines a first side 82a and a second side 82b and has a first end 83a and a second end 83b. The heat exchanger 40 has an internal pathway 84 defined by the baffle plates 80. As shown in FIG. 6, the internal pathway 84 is divided into a first segment 86a corresponding to the first side 82a and a second segment 86b corresponding to the second side 82b. The first segment 86a carries the air from the first end 83a to the second end 83b while the second segment 86b carries the air back from the second end 83b to the first end 83a. Each segment 86 and 88 extends through a plurality of 180 degree turns. As previously referenced, the first segment 86a directs the air flow in a generally first direction. The second segment 86b directs the flow of air in a generally second, opposite direction. This configuration allows air flow traveling along a single internal pathway as defined by the baffle plates 80 to have parallel flow, counter flow, and cross-flow components relative to the air flow F through the plenum 62 over the outer surface 50 of the heat exchanger housing 44. In particular, the first segment 86a is adapted for both parallel and cross-flow modes of heat exchange while the second segment 86b is adapted for both counter flow and cross-flow modes of heat exchange.

[0045] As shown in FIG. 7, some embodiments of the heat exchanger 40 include baffle plates 80 defining two internal pathways 90 and 92. Exhaust air flows from the combustion chamber 22 (see FIGS. 1-4) into the first end 48 of the heat exchanger 40 where it is split and travels along
internal pathways 90 and 92. Each internal pathway 90 and 92 extends through a plurality of 180 degree turns. In some embodiments, the directions of air flow along a substantial portion of the first and second pathways 90, 92 are in generally parallel, though opposite direction. The air flowing through each pathway 90 and 92 converges back together at the second end 52 of the heat exchanger 40 before being exhausted.

[0046] Various embodiments of a heat exchanger according to the present invention increase the overall efficiency otherwise achieved using heat generating devices such as gas fireplaces. For reference, overall energy efficiency or Annual Fuel Utilization Efficiency (AFUE) is calculated according to the Department of Energy Testing procedure (10 CFR Part 430). Where the fuel being consumed within the heat generating device, for example natural gas, has a moisture content of about 6% to about 7% energy efficiency of about 93% is an approximate upper limit for the system 10. Thus, in some embodiments, the system 10 includes a natural gas fireplace heat generating device and is adapted to achieve an energy efficiency of about 93%. According to further embodiments, the system 10 is adapted to have an energy efficient ranging from about 75% to about 93%. According to still further embodiments, the system 10 is adapted to have an energy efficient ranging from about 90% to about 93%, for example.

[0047] Various modifications and additions can be made to the exemplary embodiments discussed without departing from the scope of the present invention. For example, while the embodiments described above refer to particular features, the scope of this invention also includes embodiments having different combinations of features and embodiments that do not include all of the described features. Accordingly, the scope of the present invention is intended to embrace all such alternatives, modifications, and variations as fall within the scope of the claims, together with all equivalents thereof.
CLAIMS

What is claimed is:

1. A fireplace heat exchange system comprising:

   a firebox including a plurality of panels combining to define a combustion chamber having a combustion inlet port in fluid communication with a source of combustion air and an exhaust outlet port;

   a combustion element adapted to generate heat and exhaust products in the combustion chamber via combustion of a fuel source with combustion air received through the combustion inlet port;

   a plenum defining an air intake end and an air output end, the plenum including a plurality of walls combining to define an air pathway between the air intake and air output ends; and

   a first heat exchanger including:

   a housing having an outer surface disposed within the plenum, the housing defining a first end in fluid communication with the exhaust outlet port and a second end; and

   a plurality of baffle plates within the housing, the plurality of baffle plates defining at least a first internal pathway within the outer housing, the first internal pathway extending through a plurality of 180 degree turns from the first end of the heat exchanger to the second end of the heat exchanger.
2. The system of claim 1, further comprising a first air assist device adapted to promote a flow of the exhaust products out of the combustion chamber through the exhaust outlet port, through the first internal pathway of the heat exchanger, and out of the distal end of the heat exchanger.

3. The system of claim 1, wherein the air output end is in fluid communication with a living space, the system further comprising a second air assist device adapted to draw air through the air pathway over the outer surface of the heat exchanger and into the living space.

4. The system of claim 1, wherein the first internal pathway of the heat exchanger defines a counter flow component relative to the air pathway between the air intake and air output ends of the plenum.

5. The system of claim 1, wherein the first internal pathway of the heat exchanger further defines a cross-flow component relative to the air pathway between the air intake and air output ends of the plenum.

6. The system of claim 1, further comprising a second internal pathway within the housing separate from the first internal pathway, the second internal pathway extending through a plurality of 180 degree turns from the proximal end of the heat exchanger to the distal end of the heat exchanger.

7. The system of claim 1, wherein the outer surface of the heat exchanger housing includes a plurality of heat transfer assist structures.

8. The system of claim 1, further comprising a second heat exchanger in fluid communication with the first heat exchanger, the second heat exchanger including:

   a housing having an outer surface disposed within the plenum,
   the housing defining a first end in fluid communication
with the second end of the first heat exchanger and a second end; and

a plurality of baffle plates, the plurality of baffle plates defining at least a first internal pathway within the housing, the first internal pathway extending through a plurality of 180 degree turns from the first end of the second heat exchanger to the second end of the second heat exchanger.

9. The system of claim 8, wherein the second heat exchanger is fluidly coupled to the first heat exchanger in a generally stacked relationship such that the second heat exchanger is spaced a distance from the first heat exchanger, wherein air flows between the outer surfaces of the second heat exchanger and the first heat exchanger.

10. A fireplace heat exchange system located within a building structure having a plurality of walls defining at least one living space, the system comprising:

a plenum defining an air intake end and an air output end, the plenum including a plurality of walls defining an air pathway between the air intake and air output ends;

a firebox located within the plenum, the firebox including a plurality of panels defining a combustion chamber having at least one combustion inlet port in fluid communication with a combustion air source, and an exhaust air outlet port;

a combustion element adapted to generate heat and exhaust products in the combustion chamber via combustion of a fuel source with combustion air received through the combustion inlet port; and
a first heat exchanger mounted to the firebox located within the plenum, the first heat exchanger including:

a housing having an outer surface disposed within the plenum, the housing defining a first end in fluid communication with the exhaust outlet port and a second end; and

a plurality of baffle plates within the housing, the plurality of baffle plates defining at least a first internal pathway within the outer housing, the first internal pathway extending through a plurality of 180 degree turns from the first end of the heat exchanger to the second end of the heat exchanger.

11. The system of claim 10, further comprising a first air assist device adapted to promote a flow of the exhaust products out of the combustion chamber through the exhaust outlet port, through the first internal pathway of the heat exchanger, and out of the distal end of the heat exchanger.

12. The system of claim 10, wherein the air output end is in fluid communication with a living space, the system further comprising a second air assist device adapted to draw air through the air pathway over the outer surface of the heat exchanger and into the living space.

13. The system of claim 10, the first heat exchanger further comprising a first portion in fluid communication with a second portion, wherein the first portion is angularly offset from the second portion by at least ninety degrees.
14. The system of claim 10, wherein the housing of the first heat exchanger shares a common panel with the firebox to which the first heat exchanger is mounted, wherein no space exists between an outer surface of the firebox and the outer surface of the heat exchanger housing.

15. The system of claim 10, wherein the first heat exchanger is mounted to the firebox such that it is spaced a distance from an outer surface of the firebox, wherein air is permitted to flow between the outer surface of the first heat exchanger housing and the outer surface of the firebox.

16. The system of claim 10, wherein the outer surface of the heat exchanger housing includes a plurality of heat transfer assist structures.

17. The system of claim 10, further comprising a second heat exchanger in fluid communication with the first heat exchanger, the second heat exchanger including:

- a housing having an outer surface disposed within the plenum, the housing defining a first end in fluid communication with the second end of the first heat exchanger and a second end; and

- a plurality of baffle plates, the plurality of baffle plates defining at least a first internal pathway within the housing, the first internal pathway extending through a plurality of 180 degree turns from the first end of the second heat exchanger to the second end of the second heat exchanger.
18. The system of claim 17, wherein the second heat exchanger is fluidly coupled to the first heat exchanger in a generally stacked relationship such that the second heat exchanger is spaced a distance from the first heat exchanger, wherein air flows between the outer surfaces of the second heat exchanger and the first heat exchanger.

19. A method of transferring heat from a combustion chamber to air to be delivered to a living space, the method comprising:

- passing hot exhaust air from a combustion chamber into a first heat exchanger located within a plenum having a plurality of walls defining an air pathway between an air intake end and an air output end, the heat exchanger including a housing defining an exhaust air inlet and an exhaust air outlet, the housing having an outer surface and a plurality of baffle plates within the housing defining an internal pathway from the exhaust air inlet to the exhaust air outlet, causing the exhaust air to flow along the first internal pathway through a plurality of 180 degree turns from the exhaust air inlet of the heat exchanger to the exhaust air outlet of the heat exchanger; and

- passing air through the plenum along the air pathway between the air intake and air output end and over the outer surface of the heat exchanger housing such that heat is transferred from the combustion chamber to the air passing through the plenum and from the relatively hot exhaust air passing through the heat exchanger to the air passing through the plenum.

20. The method according to claim 19, further comprising creating positive pressure within the combustion chamber to assist passing exhaust air from the combustion chamber to the heat exchanger, and along the internal pathway located within the heat exchanger housing.
21. The method according to claim 19, further comprising assisting passage of the air through the plenum from the input end to the output end and into the living space.

22. The method according to claim 19, further comprising passing the relatively hot exhaust air from the first heat exchanger to a second heat exchanger located within the plenum, the second heat exchanger in fluid communication with the exhaust air outlet of the first heat exchanger, the second heat exchanger including a housing defining an exhaust air inlet and an exhaust air outlet, the housing having an outer surface and a plurality of baffle plates within the housing, the plurality of baffle plates defining at least a first internal pathway within the housing, the first internal pathway extending through a plurality of 180 degree turns from the exhaust air inlet of the heat exchanger to the exhaust air outlet of the heat exchanger.

23. The method according to claim 19, wherein transferring heat from the combustion chamber to the air passing through the plenum and from the relatively hot exhaust air passing through the heat exchanger to the air passing through the plenum achieves an overall efficiency greater than about 90%.
Fig. 6
### A. CLASSIFICATION OF SUBJECT MATTER

**INV. F24B7/02**

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 1 383 506 A (CHARLIE WESTERLUND) 5 OuIy 1921 (1921-07-05)</td>
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* Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search:

21 April 2009

Date of mailing of the international search report:

28/04/2009

Name and mailing address of the ISA:

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Authorized officer:

Verdoodt, Luk
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