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(54) **ATMOSPHERIC HOT WATER HEATING SYSTEM**

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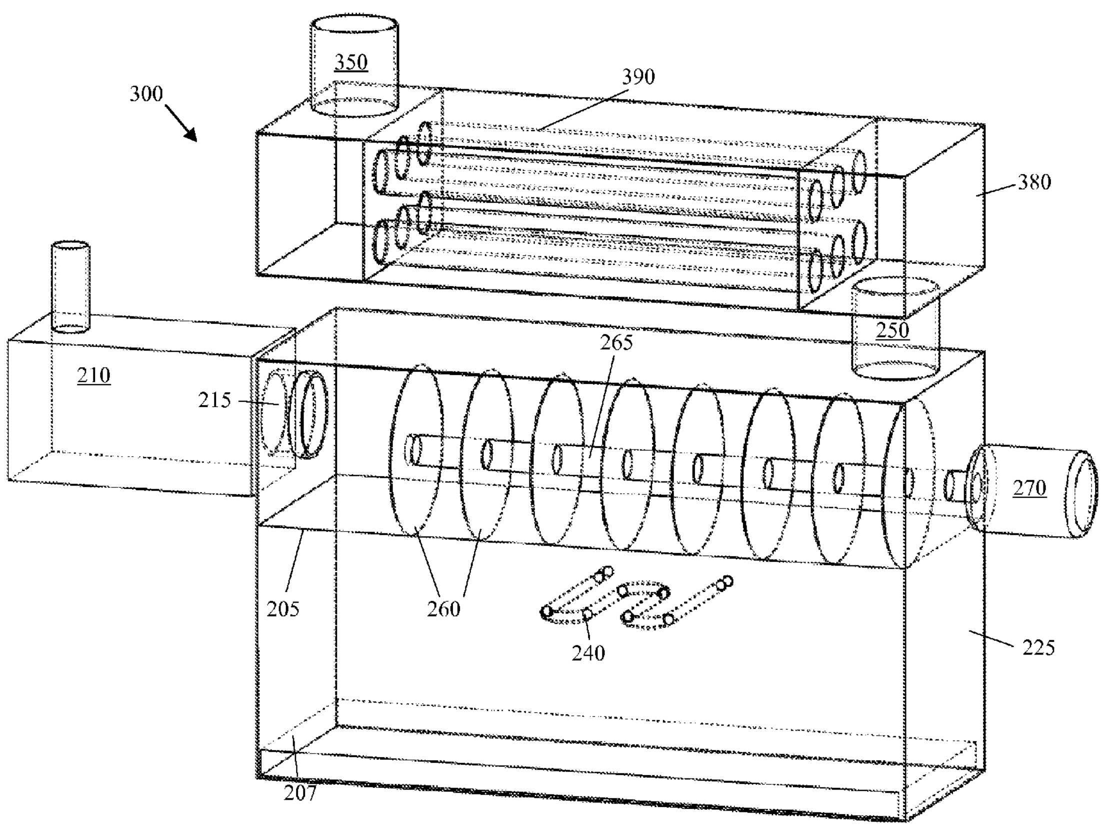
(57) **ABSTRACT**

An atmospheric water heating system is presented, where hot gasses from a burner are introduced directly to water. The water is exposed to the burner exhaust gasses as a film upon a series of rotating discs partially submerged in a reservoir. The water vaporizes and then re-condenses on subsequent discs, cooling the exhaust gas and heating the reservoir water. The heated reservoir water may be used to heat space heating water with a water-to-water heat exchanger. The water vapor may be used to heat environmental forced hot air with a vapor-to-air heat exchanger.



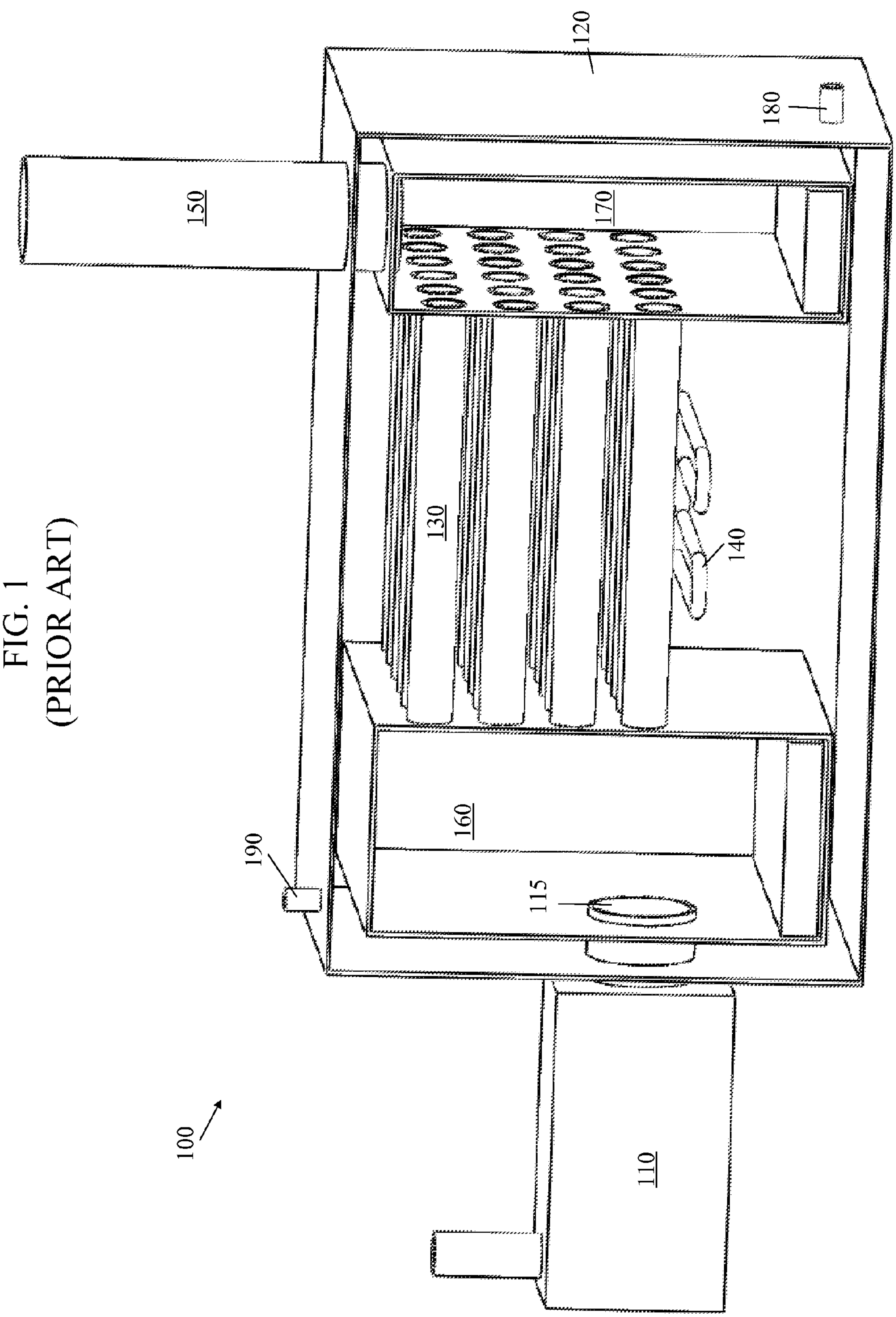


FIG. 1
(PRIOR ART)

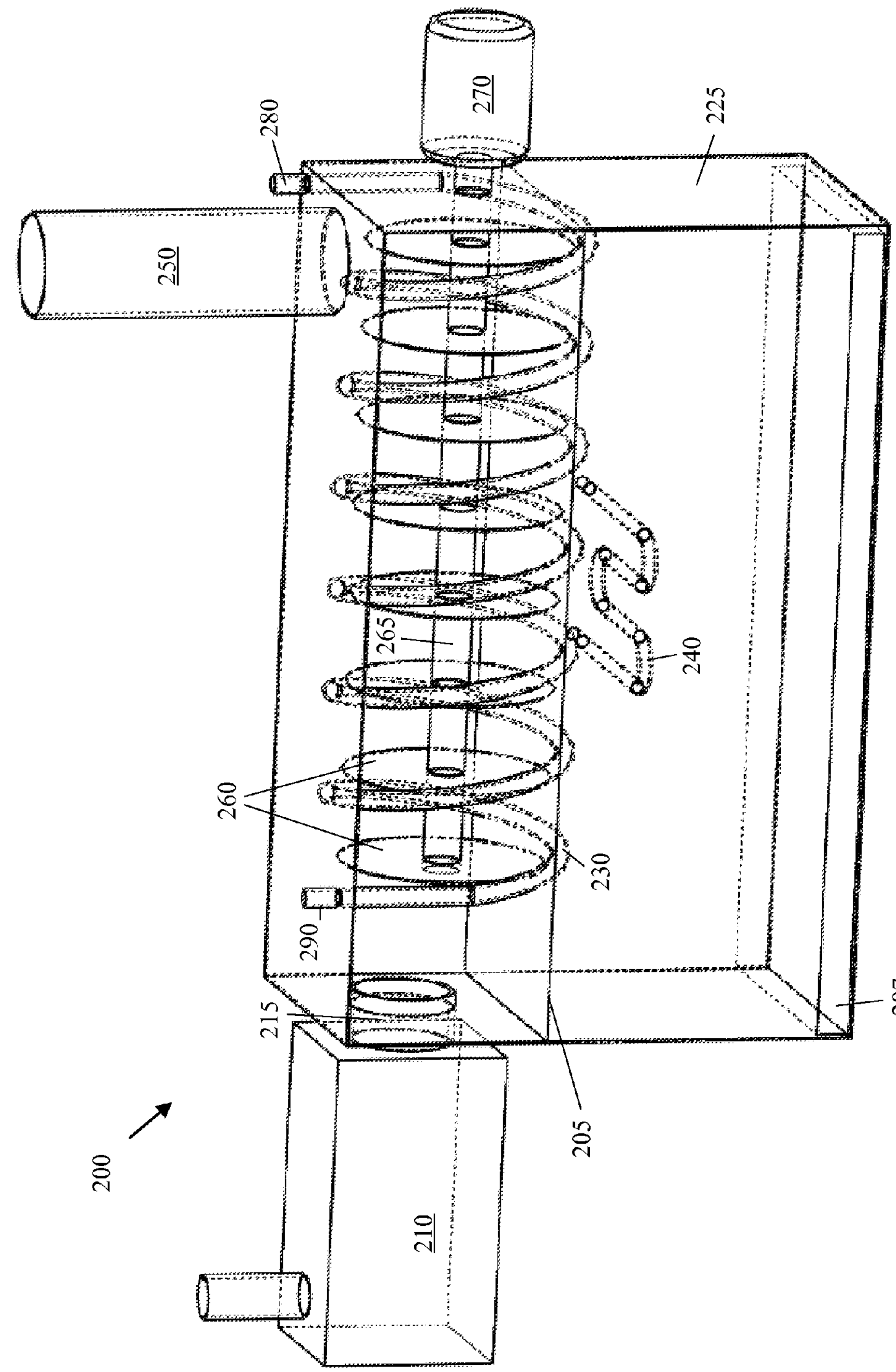


FIG. 2A

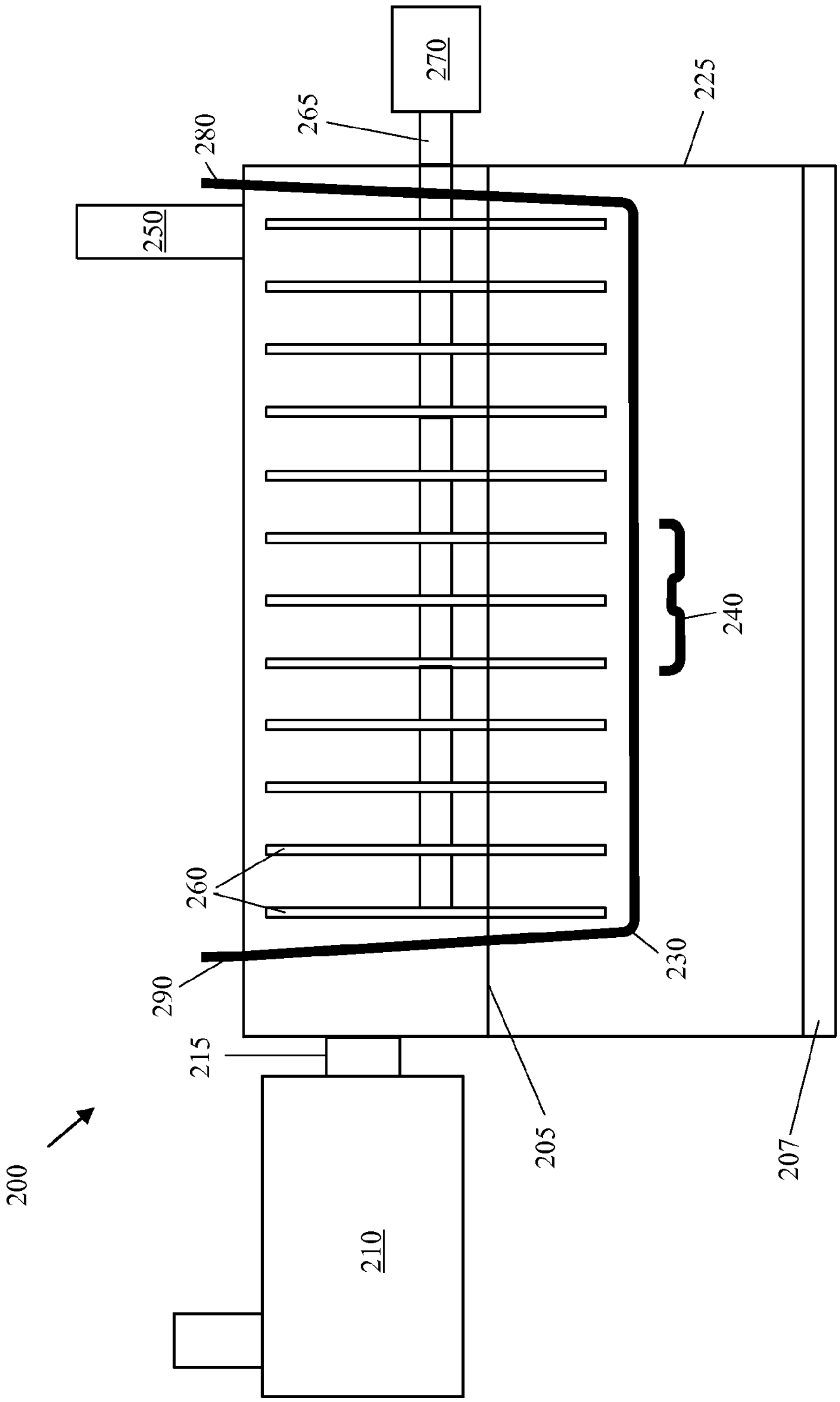


FIG. 2B

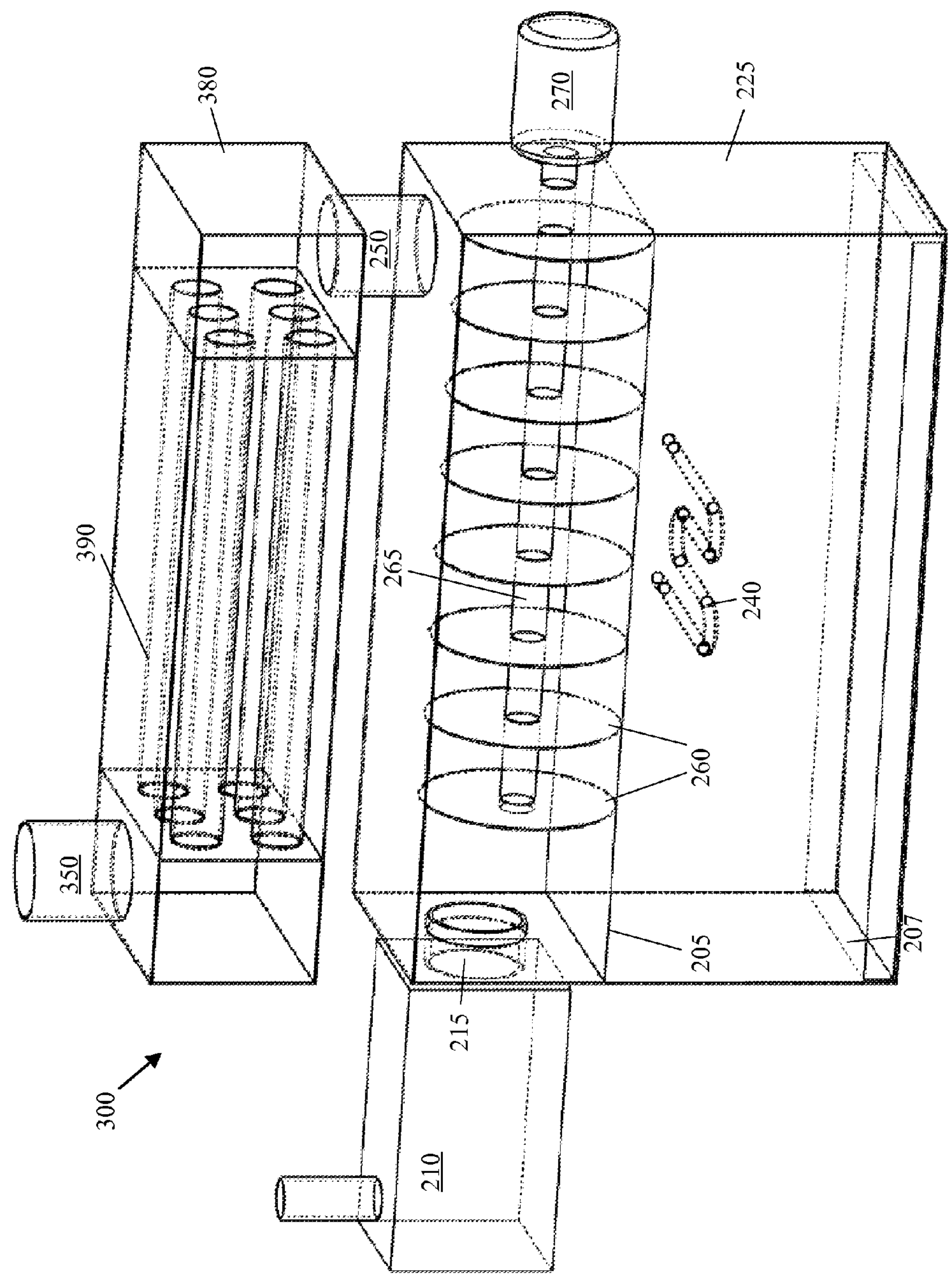


FIG. 3A

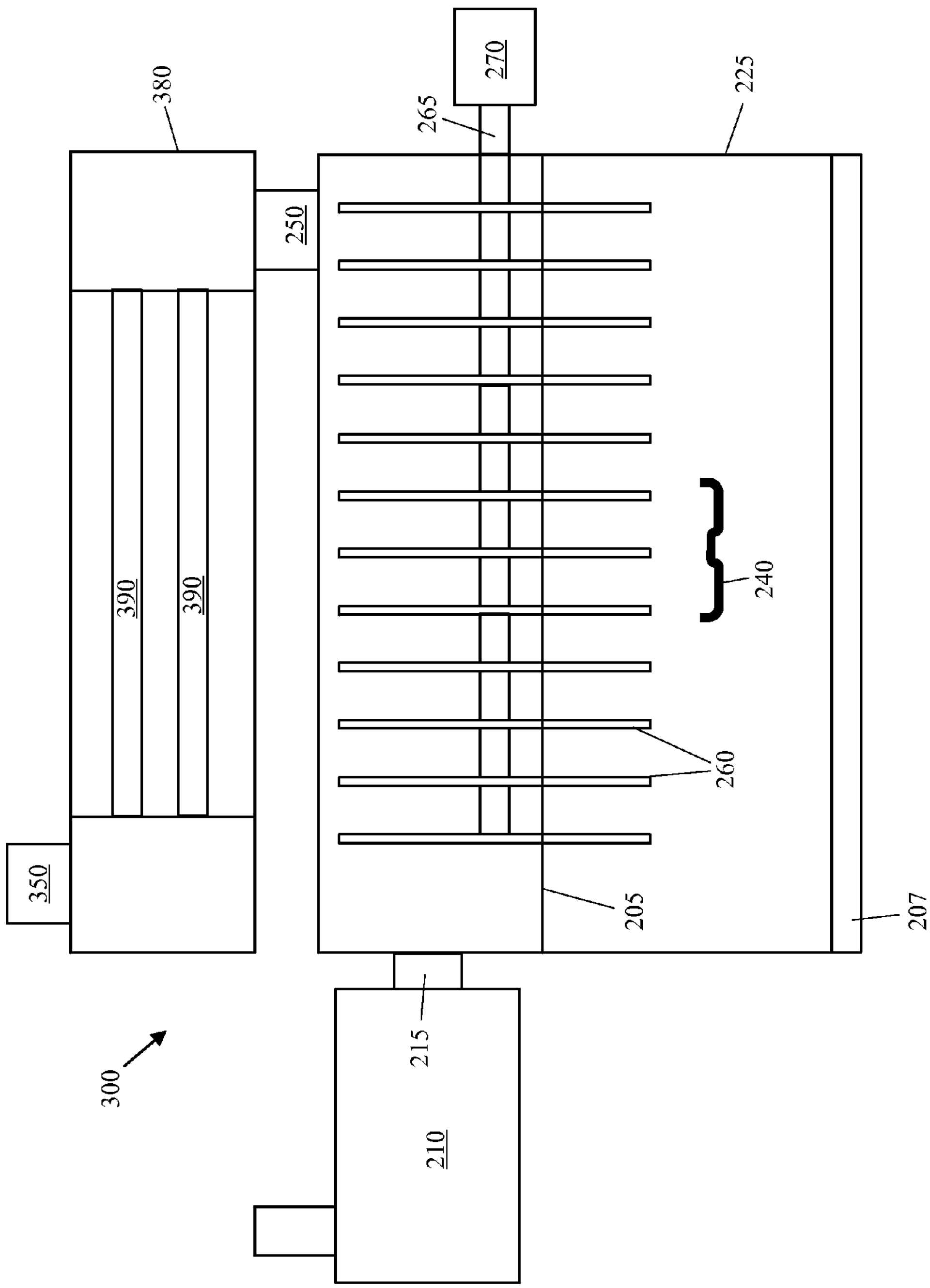


FIG. 3B

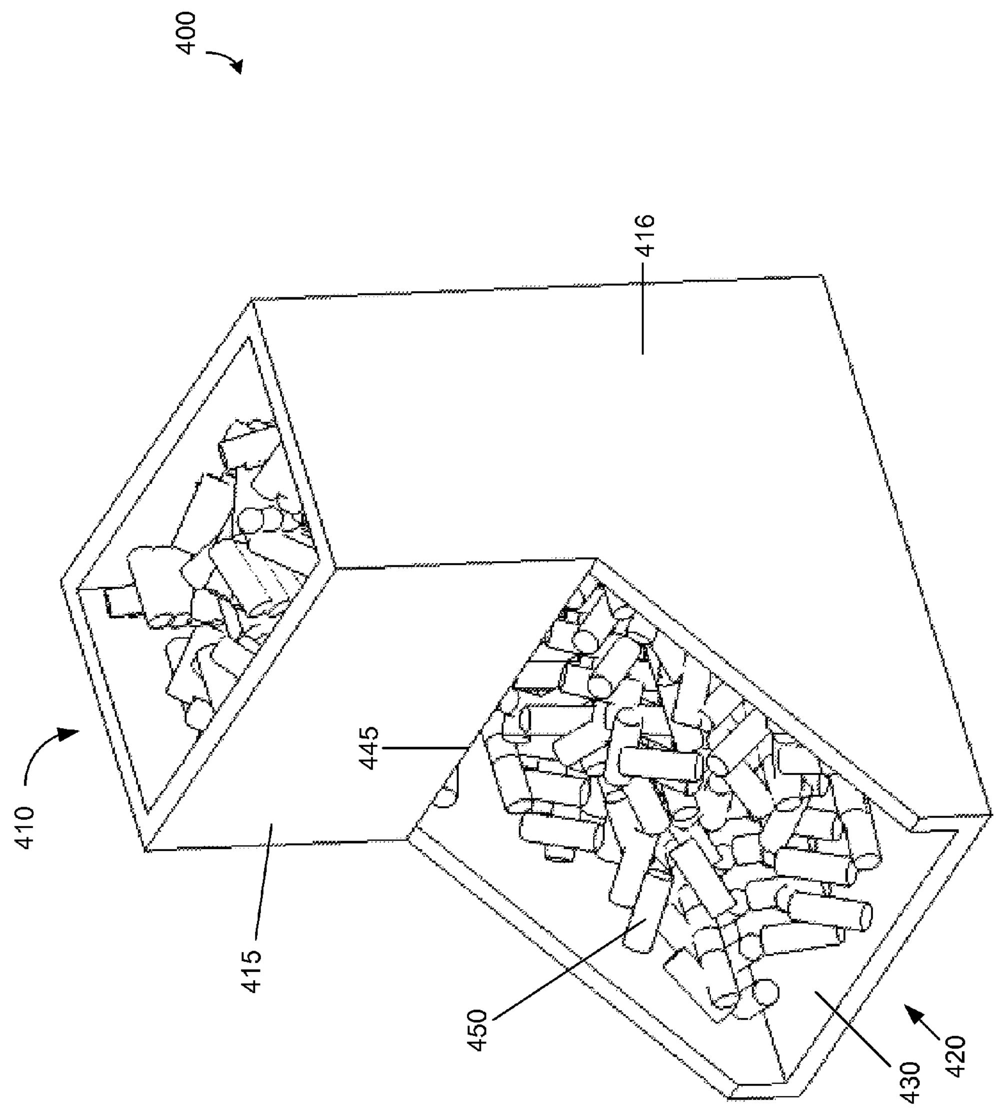


FIG. 4

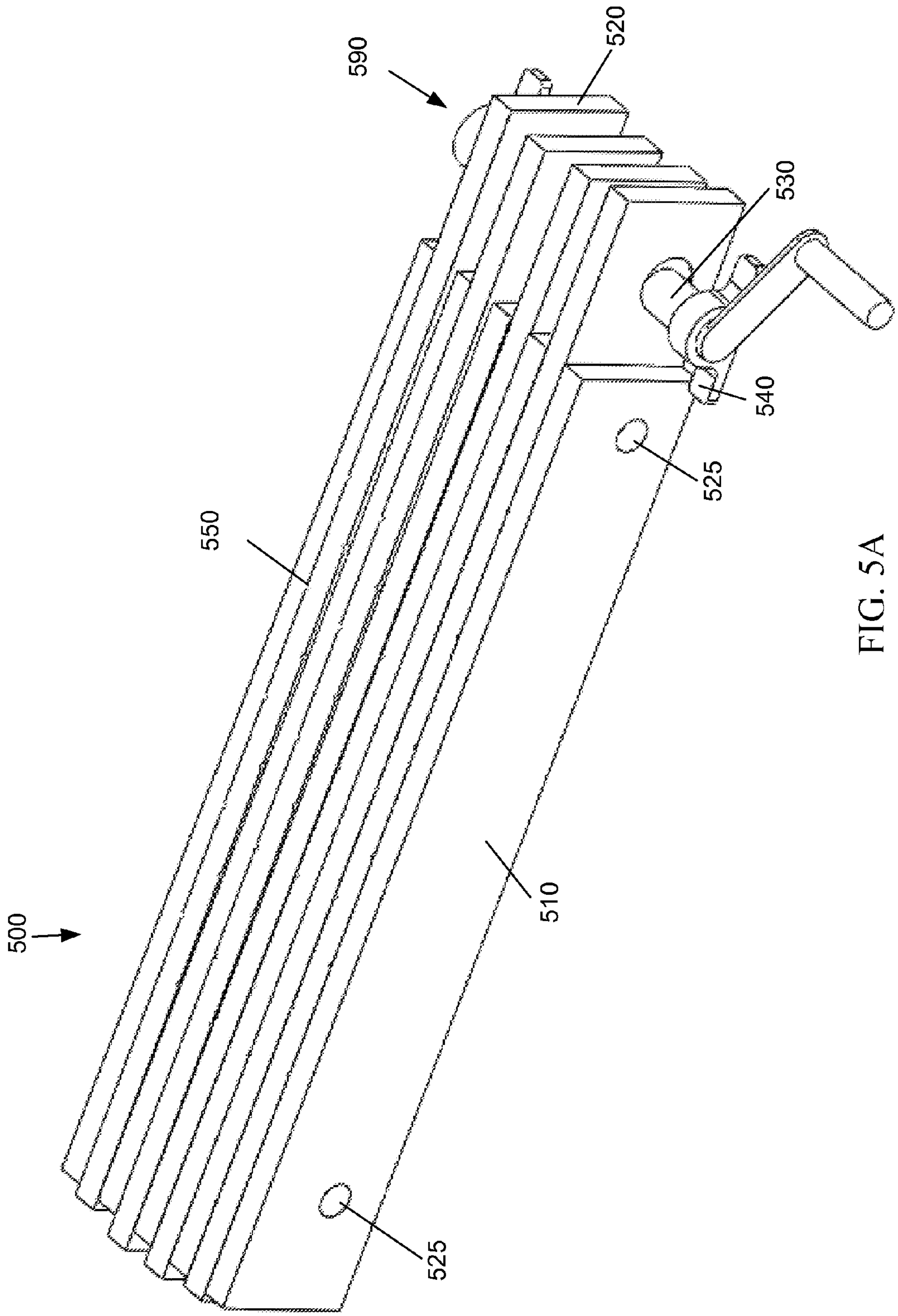


FIG. 5A

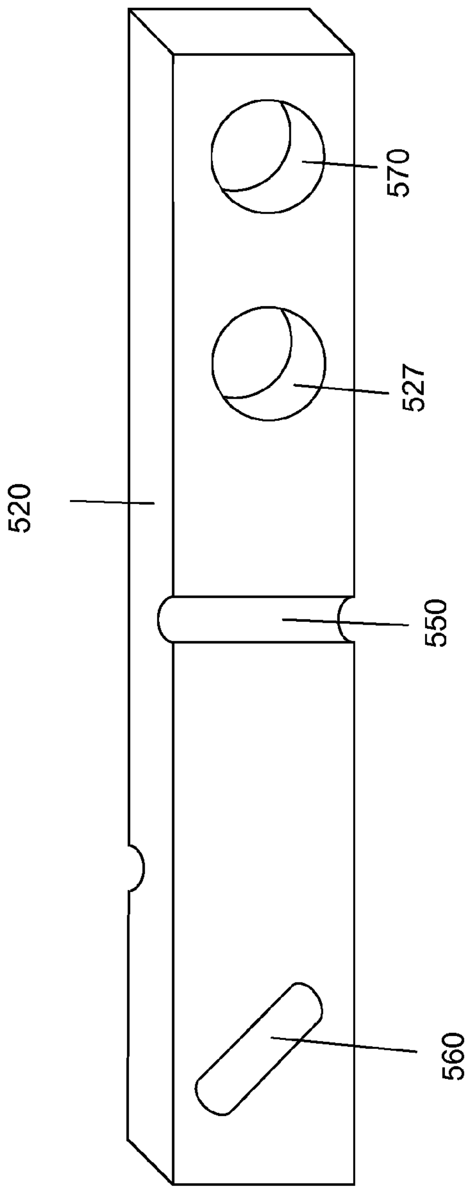


FIG. 5B

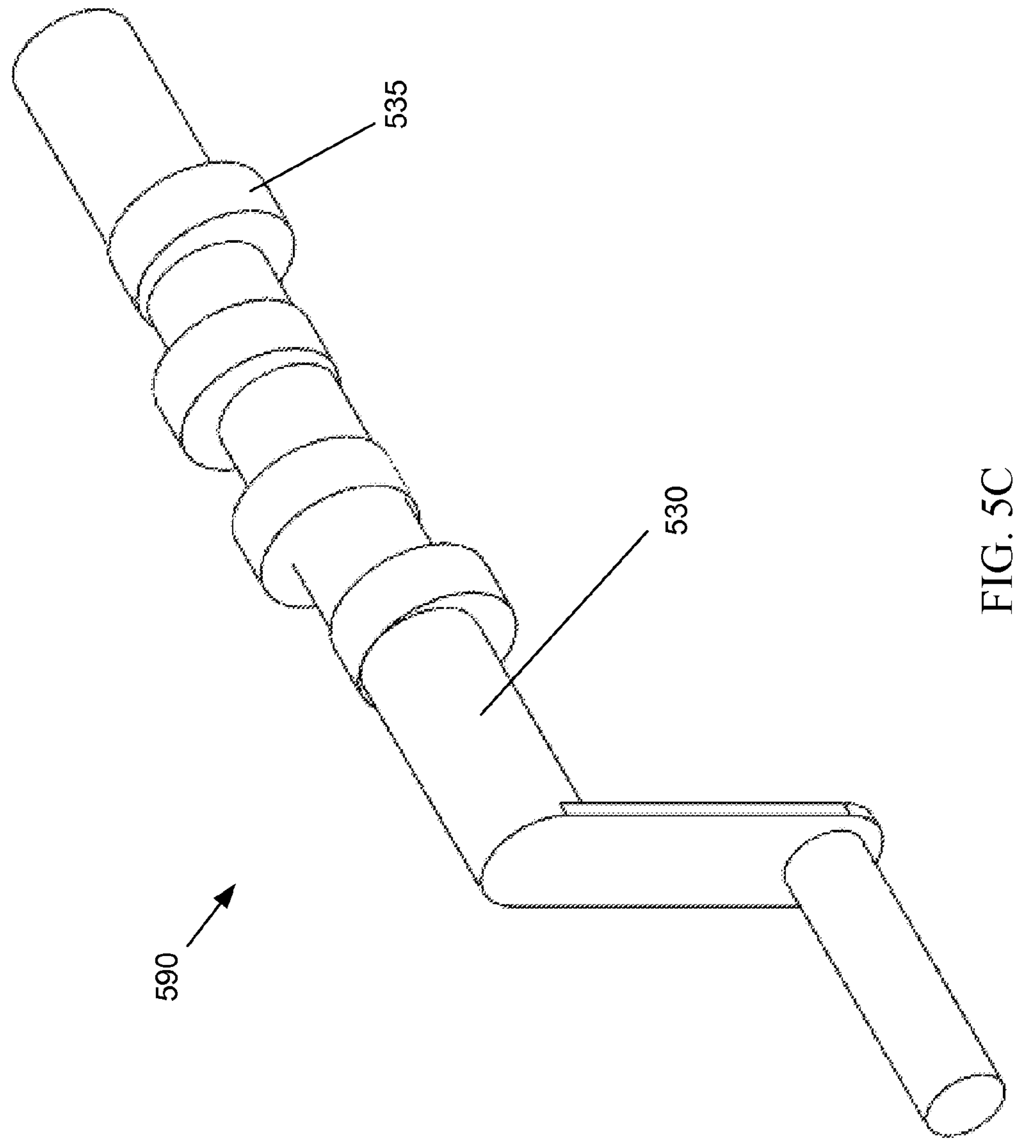


FIG. 5C

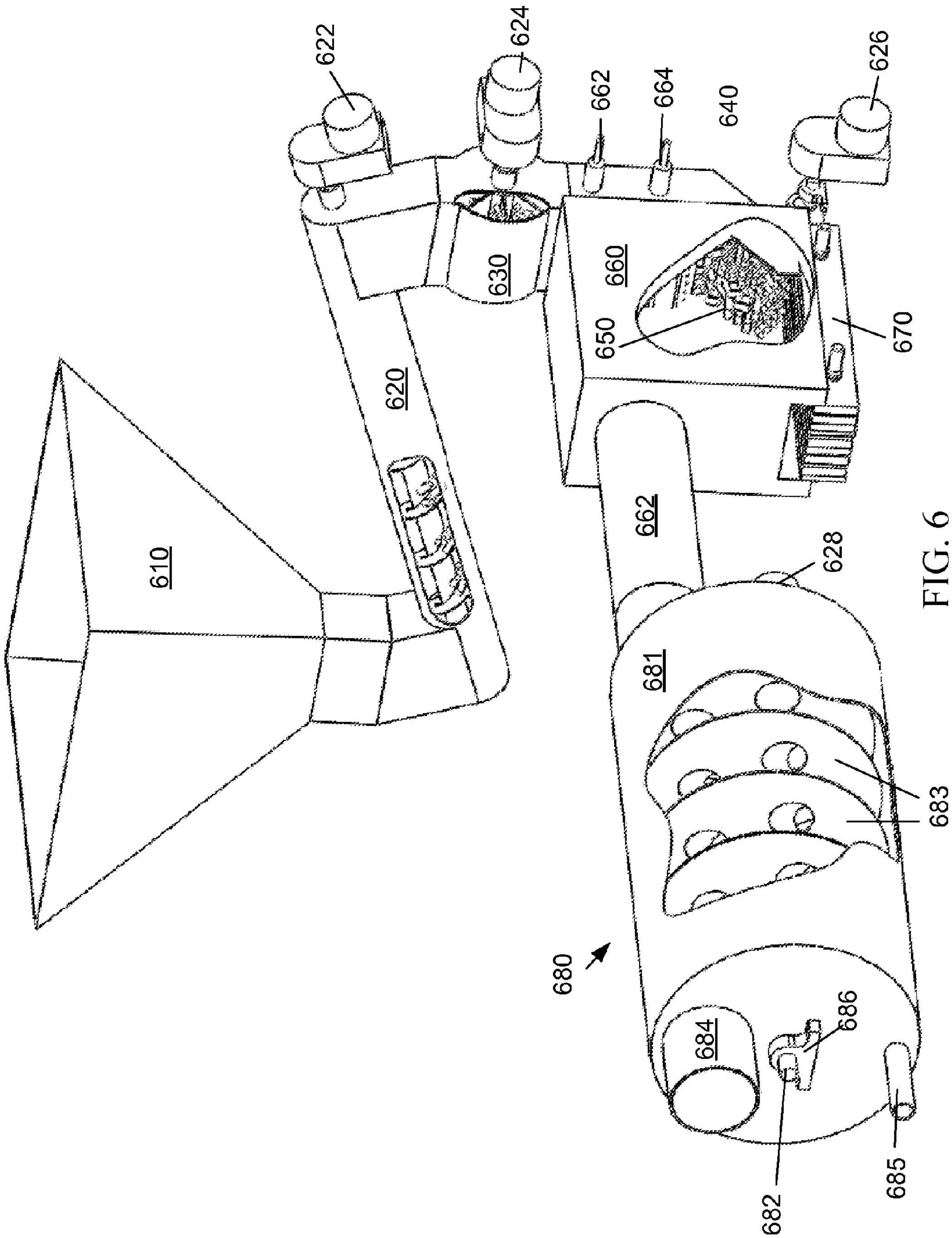

622
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FIG. 6

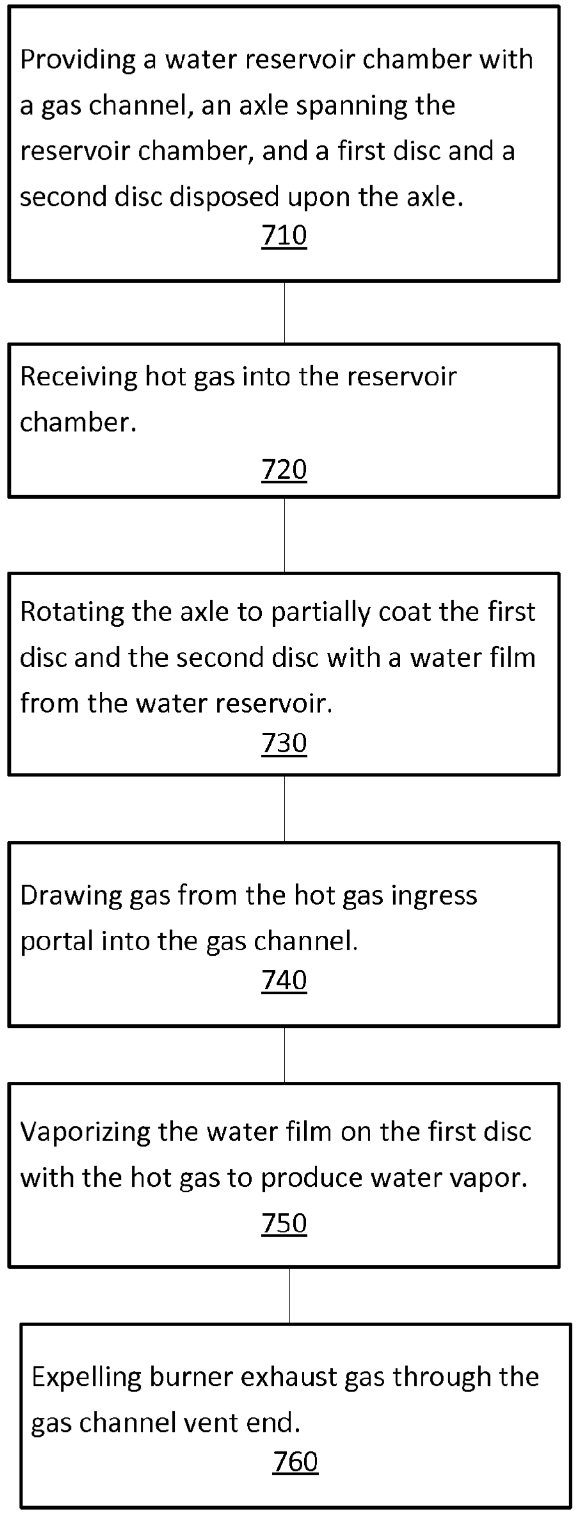
Providing a water reservoir chamber with a gas channel, an axle spanning the reservoir chamber, and a first disc and a second disc disposed upon the axle.
710
Receiving hot gas into the reservoir chamber.
720
Rotating the axle to partially coat the first disc and the second disc with a water film from the water reservoir.
730
Drawing gas from the hot gas ingress portal into the gas channel.
740
Vaporizing the water film on the first disc with the hot gas to produce water vapor.
750
Expelling burner exhaust gas through the gas channel vent end.
760

FIG. 7

ATMOSPHERIC HOT WATER HEATING SYSTEM

FIELD OF THE INVENTION

[0001] The present invention relates to space heaters, and more particularly, is related to an atmospheric pressure space heating boiler.

BACKGROUND

[0002] Pressurized boiler technology is well known. The prior art contains multiple examples of devices that heat water for use in home or business space heating and domestic hot water. Since these boilers operate under high pressure, the components are required to meet the American Society for Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), resulting in boilers that are bulky, heavy and expensive. The boilers burn fuel, for example, oil, natural gas or coal, and the flame or exhaust gas from the combustion chamber, or burner, is exposed water in a water vessel via a heat exchanger. The heat exchanger may be, for example, one or more pipes that convey the hot exhaust gas through the water vessel. The hot exhaust gas heats the pipes, and the pipes conduct the heat to the water in the vessel. Therefore, the water is heated indirectly, by heating portions of the water vessel, for example, a pipe, that in turn transfers the heat to the water. These water vessels are pressurized to withstand the pressure of the heated water and expanding steam as it approaches the boiling point, and therefore are typically built to ASME BPVC specifications. In contrast, a boiler that is not enclosed is known as an atmospheric boiler.

[0003] FIG. **1** shows a prior art pressurized boiler **100**. Fuel is burned by a burner **110**, and hot exhaust gas from the burner **110** enters an ingress chamber **160** of a water vessel **120** through a burner exhaust vent **115**. The water vessel **120** is substantially filled with water. The hot exhaust gas then passes through an air-to-water heat exchanger **130**, where heat from the hot exhaust gas is transferred to water in the water vessel **120**. The exhaust gas then enters an egress chamber **170**, before being expelled from the boiler **100** through an exhaust vent **150**. In some cases, the vented exhaust gas is still hot, so some energy from the combustion process is not utilized by the boiler **100**. This results in a lower efficiency heating system. Of course, the heat exchanger tubes may be horizontal or vertical, and the chambers may be baffled so that gas passes back and forth for desired results.

[0004] In the pressurized boiler **100**, the heated water is pumped directly from the water vessel **120** through a hot water outlet **190** and circulated through hot water pipes, where the heat from the hot water is conveyed to warm the environment, for example by water filled radiators or radiant floor heating tubes. The water circulates through the heating system, and then is returned to the water vessel in the boiler through a cold water inlet **180**. In a pressurized boiler the temperature of the return water may impact factors such as the efficiency of the boiler **100**.

[0005] Pellet burners provide unique challenges. The pellets must be continuously fed to the burner to maintain constant heat output and high efficiency. While liquid fuel or gas and propane burners may be regulated by forcing the fuel by pressure or by gravity, pellet feeders typically require mechanical means to transport fuel to the burner. Examples include augers and conveyor belts. These mechanical pellet feeders add costs to the boiler, consume energy and require maintenance.

[0006] Besides requiring power to operate and downtime to maintain, the mechanical feeders may not feed the pellets to the burner at an optimum rate. Even if the feed rate is initially correctly tuned for an optimum burn rate, variations in the feed or other conditions may require adjustment of the feed rate. Such adjustment may be impractical, particularly if the feed pellet consistency varies often.

[0007] For the purposes of this application, the angle of repose is defined as the steepest angle of descent of the slope relative to the horizontal plane when material on the slope face is on the verge of sliding. This angle may be between the angle of 0° and 90°. When bulk granular material is poured onto a horizontal surface a generally conical pile forms. Granular material piled at the angle of repose of that material may be thought of as being at an equilibrium point. If the angle of the material is increased past the angle of repose, the material begins to flow. If the angle is decreased below the angle of repose, additional material may accumulate before the material tends to flow.

[0008] When particles are removed from the base of the conical pile, particles uphill from the removed particles generally flow downward under the force of gravity to fill the space created by the removed particles. The internal angle between the surface of the pile and the horizontal surface is known as the angle of repose. The angle of repose for a particulate material is related to physical properties of the particles such as the density surface area and geometry of the particles, and the coefficient of friction of the material. Material with a low angle of repose forms flatter piles than material with a high angle of repose. Material with generally uniform physical properties tends to have a consistent and predictable angle of repose.

[0009] In addition to requiring a constant flow of fresh pellets, the spent fuel in a pellet burner must be removed. When pellets are burned, they produce particle emissions, known a fly ash, and leave spent fuel behind, known as heavy ash. The heavy ash can clog the airways required in the burner for efficient combustion. Therefore, the heavy ash must be systematically removed as fresh pellets are replenished. Further, the ash should not be removed until the combustible material in the pellet is fully spent. Mechanized conveyor methods should thus be monitored so the feed is not moved through the burner too quickly, resulting in removing unspent fuel and producing additional waste material, or too slowly, reducing burner efficiency. Therefore it is desirable to develop a low power pellet feeder that self adjusts the feed rate to the optimal burn efficiency.

[0010] Heavy ash, fly ash, and clinkers must be disposed of. In some jurisdictions, the fly ash must be removed from the exhaust gas exiting the burner to meet fine particle emissions standards. Prior art methods for removing fly ash include the use of mesh air filters and water sprays. Air filters must generally be deployed after the exhaust burner gasses have cooled somewhat, and the air filters must be periodically replaced. Removing particulates with water spray requires energy to pump the water, and the spray nozzles may become clogged, for example, with particulates.

[0011] The heavy ash must be cleared from the burner to make way for fresh pellets. A known method for removing ash from a burner is to agitate the burning surface, or grate, so that the spent ash drops away through openings in the grate.

However, such agitating grates have heretofore been excessively power consuming, complex, and expensive, making them impractical for some applications, for example, domestic or other low cost installations. Therefore a need exists for a simple, low power agitating grate.

[0012] The spent fuel from the pellet burner, for example, ash, must be stored until it can be disposed of. Since ash is highly friable, it can be difficult to handle and transport. Since ash continues to accumulate during operation of a pellet burner, the ash must be periodically removed from the system. Therefore, a pellet burner requires regular maintenance. It is desirable to minimize the maintenance of a pellet burner.

[0013] Prior art boilers generally operate with a large number of components operating within a pressurized vessel in order to comply with ASME codes. Components meeting these standards are generally constructed from heavy and expensive materials. It is therefore desirable to minimize the number of boiler components operating above one atmosphere of pressure. Similarly, it is desirable to reduce the power required to feed a pellet burner, to reduce fly ash emissions, to reduce the frequency of pellet boiler maintenance, and to reduce the costs associated with manufacturing and operating the pellet boiler.

SUMMARY

[0014] Embodiments of the present invention provide a system and method for an atmospheric boiler. Briefly described, the present invention is directed to an atmospheric space heater, including a burner with an exhaust gas portal, and a reservoir chamber having a water reservoir and a gas channel in contact with the water reservoir, the gas channel further including a burner side and an egress side, the egress side disposed substantially opposite the burner side, the burner exhaust gas portal in communication with the reservoir chamber gas channel burner side.

[0015] The burner further includes a rotatable axle disposed within the gas channel, at least partially spanning the reservoir chamber gas channel from the burner side to the egress side, and a plurality of spaced discs disposed upon the axle configured to rotate in rigid accompaniment with the axle, the axle disposed within the reservoir chamber such that the plurality of discs are partially submerged in the water reservoir and partially within the air chamber.

[0016] A second aspect of the present invention is directed to a method for space heating. Briefly described, the method includes the step of providing a boiler having a burner, a reservoir chamber including a water reservoir and a gas channel above the water reservoir, wherein the gas channel is in direct physical contact with the water reservoir, the gas channel having a hot gas ingress end in communication with the burner, and a vent end, a rotatable axle at least partially spanning the reservoir chamber, the axle disposed substantially through the gas channel, a first disc disposed upon the axle, the first disc disposed partially submerged in the water reservoir, the first disc configured to rotate in rigid conformity with the axle, the first disc disposed substantially at the hot gas ingress end of the gas channel, and a second disc disposed upon the axle, the second disc disposed partially submerged in the water reservoir, the second disc configured to rotate in rigid conformity with the axle, the second disc disposed substantially at the vent end of the axle.

[0017] The method also includes the steps of burning fuel in a burner, thereby producing hot gas, conveying the hot gas from the burner into the hot gas ingress portal, rotating the axle, thereby partially coating the first disc and the second disc with a water film from the water reservoir, drawing gas from the hot gas ingress portal into the gas channel, and expelling burner exhaust gas through the gas channel vent end.

[0018] Briefly described, in architecture, a third aspect of the present invention is directed to a system for a pelletized fuel burning indoor space heating system having an angle of repose pelletized fuel feeder, an oscillating pelletized fuel burner grate configured receive pellets from the fuel feeder, a pelletized fuel burner configured to burn pellets on the oscillating grate, a reservoir chamber partially filled with water configured to receive exhaust gas from the fuel burner, and an axle including a plurality of partially submerged spaced discs rotatably disposed within the reservoir chamber.

[0019] Briefly described, in architecture, a fourth aspect of the present invention is directed to a boiler, having a water tank, a solid fuel burner configured to transfer heat from the burner to the water tank, and means for transferring spent fuel from the fuel burner into the water tank.

[0020] Other systems, methods and features of the present invention will be or become apparent to one having ordinary skill in the art upon examining the following drawings and detailed description. It is intended that all such additional systems, methods, and features be included in this description, be within the scope of the present invention and protected by the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principals of the invention.

[0022] FIG. **1** is a diagram of a prior art boiler.

[0023] FIGS. **2**A and **2**B are diagrams of the first embodiment of an atmospheric boiler.

[0024] FIGS. **3**A and **3**B are diagrams of a second embodiment of an atmospheric furnace.

[0025] FIG. **4** is a diagram of a gravity pellet feeder.

[0026] FIGS. **5**A, **5**B, and **5**C are diagrams of three views of a simplified agitating grate.

[0027] FIG. **6** is a diagram of an exemplary system containing an atmospheric water heater, a simplified agitating grate and a gravity pellet feeder.

[0028] FIG. **7** is a flowchart of an exemplary method of heating water.

DETAILED DESCRIPTION

[0029] Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0030] An atmospheric space heater is presented, where hot gasses from a burner are introduced directly to water. The water is exposed to the burner exhaust gasses as a film upon a series of rotating discs partially submerged in a reservoir. The water vaporizes and then re-condenses on subsequent discs, cooling the exhaust gas and heating the reservoir water. The heated reservoir water may be used to heat water with a water-to-water heat exchanger. The water vapor may be used to heat environmental forced hot air with a vapor-to-air heat exchanger. A simplified agitating burner grate and a gravity pellet feeder are likewise presented.

[0031] Atmospheric Water Heater

[0032] FIGS. **2**A and **2**B show a first embodiment of an atmospheric water heater **200**. The atmospheric space heater is described further in the co-pending U.S. patent application Ser. No. 13/692,316 entitled "Gas-To-Liquid Heat Exchanger and Gas Particulate Scrubber," which is incorporated by reference herein in its entirety. FIG. **2**A shows a depth perspective, while FIG. **2**B shows a two dimensional cross section for clarity. Fuel combusts in a burner **210**, and the hot exhaust gas is introduced to a reservoir chamber **225**, the hot exhaust gas passing from the burner **210** to the reservoir chamber **225** through a burner exhaust vent **215** or portal. The burner **210** may burn several types of fuel, for example, but not limited to, oil, natural gas, wood, wood pellets, coal and propane.

[0033] The reservoir chamber **225** is partially filled to a water line **205** with water. The portion of the reservoir chamber **225** above the water line is called the gas channel. Unlike prior art boilers **100** (FIG. **1**), the reservoir chamber **225** need not be sealed or under pressure, but instead may be unpressurized, having a vent such as exhaust gas vent **250** open to the exterior of the heater **200**. Similarly, the gas channel in the reservoir chamber **225** may be open to the burner exhaust vent **215**, so that gas can pass freely between the burner **210** and the reservoir chamber **225**.

[0034] An axle rod **265** is connected to a motor **270**, so that the motor **270** rotates the axle rod **265**. A plurality of discs **260** are attached to the axle rod **265** so that the axle rod **265** passes substantially through the center of each disc **260**. The discs **260** are affixed to the axle rod **265** so that the discs **260** rotate in rigid accompaniment with the axle rod **265**. The axle rod **265** is disposed above the water line **205** so that the axle rod may be substantially parallel to the water line **205**, and the discs **260** are partially submerged. It should be noted that there is no objection to implementing the axle rod **265** at an angle to the water line **205**, so that discs **260** at a first end of the axle rod **265** are more submerged than discs **260** at a second end of the axle rod **265**.

[0035] The discs **260** in the first embodiment are substantially circular, but there is no objection to other shapes, such as ovals, octagons or hexagons, for example. The discs **260** may be irregularly shaped. The discs **260** need not be flat, rather, the discs **260** may be drum shaped, and may be formed of a porous material to accommodate the flow-through of vapor and/or fluid. Further, the discs **260** need not be of uniform shape and/or size, and need not be spaced along the axle **265** at regular intervals. For example, a first disc **260** in the proximity of the burner exhaust vent **215** may be configured to facilitate vaporization of water in the water reservoir **225**, and a second disc **260** in proximity of the exhaust gas vent **250** may be configured to facilitate condensation of water vapor.

[0036] As the axle **265** rotates, the discs **260** turn in the water, so that the portion of the disc **260** that is submerged emerges from the water with a thin film of water upon the surface of the disc **260**. The surface of disc **260** may be textured or scored, so that the action of rotating the discs draws more water from the reservoir. For example, there may be dimples, cuts, or slits in the discs **260** so the rotating discs **260** pick up and disperse the water, and maintain a film of water on the discs **260**. In addition, the rotating discs **260** may introduce droplets of water into the air above the water line **205**. The discs may be rotating at a relatively slow speed to minimize energy usage, for example, at approximately 150 RPM. Faster or slower disc rotation speeds are also possible. Faster rotation of the discs **260** may fling droplets of water against the inner surface of the water tank **225**, where the fluid may coalesce and re-enter the water below the water line **205** of the water tank **225**, for example, by dripping into the water tank **225** or flowing down the sides of the water tank **225**. The discs **260** may be formed of a heat resistant material such as plastics, stainless steel, or other metals.

[0037] An exhaust fan (not shown) may draw airflow from the burner **210**, through the burner exhaust vent **215**, through an air passage or channel **255** in the reservoir chamber **225** above the water line **205**, and out through the exhaust gas vent **250**. The hot burner exhaust gas may be drawn or impelled from the burner **210** into the reservoir chamber **225**, and introduced to the rotating discs **260**. Note the motor **270** used to rotate the disc axle **265** may also be used to rotate an exhaust fan (not shown).

[0038] When the hot gas from the burner **210** encounters the film of water on the disc **260** closest to the burner exhaust vent **215**, the water evaporates off of disc **260**, forming water vapor within the gas channel and cooling the gas in the gas channel. The fan draws the then cooler burner exhaust gas and the water vapor toward the second disc **260**, where the water vapor encounters the cooler water film on the disc **260**, causing at least a portion of the water vapor to re-condense, further cooling the vent exhaust gas while the re-condensed water enters the water below the water line **205** of reservoir chamber **225** as hot water. This process may repeat as the exhaust gas is drawn toward the exhaust gas vent **250** and is introduced to the water film on subsequent discs **260**. In the first embodiment of the space heater, when the gas reaches the exhaust vent **250**, the gas has generally been cooled to a temperature slightly above the temperature of the water in the reservoir chamber **225**.

[0039] Since the water vapor may immediately re-condense to hot water, it need not be maintained under pressure. By heating the water in an unpressurized, open boiler, the need for thick, heavy ASME BPVC compliant components is reduced, as the water in the reservoir chamber **225** may be heated to a temperature sufficient for space heating purposes, but still significantly below boiling temperature. Therefore, the reservoir chamber may not need to withstand pressures of prior art boilers. As a result, the materials used to construct the reservoir chamber **225** may be much lighter weight and less expensive than the materials used for prior art boilers. For example, the walls of the reservoir chamber may be constructed of thin stainless steel, which may be structurally supported by insulation, as the primary force upon the reservoir walls is from the water in the reservoir chamber **225** under the force of gravity, rather than pressure generated by heating water into water vapor. In addition, the water in the reservoir chamber **225** may act to limit the temperature of the reservoir chamber walls, further allow use of lighter weight materials by reducing the need for thick insulating metal walls.

[0040] Under the first embodiment, most of the heat from the burner exhaust gas may be transferred directly to the water in the reservoir chamber **225**. The heated water in the reservoir chamber **225** may be used to heat external water sources for space heating and domestic hot water. For example, a domestic hot water coil **240** located in the reservoir chamber

225 below the water line **205** may be used to heat domestic hot water in a manner similar to prior art boilers **100** (FIG. **1**).

[0041] Similarly, water may be introduced to a reservoir heat exchanger **230** to heat liquid for space heating purposes. Cold liquid may be introduced to the reservoir heat exchanger **230** through cold liquid inlet **280**, and the liquid in the heat exchanger **230** may be heated by the water in the reservoir chamber **225**, for example by transmitting heat from the water in the water tank **225** to the liquid within the heat exchanger tube **230**, before exiting through a hot liquid outlet **290**. The liquid within the heat exchanger tube **230** may be, for example, water, but there is no objection to using other fluids suitable for conducting heat through a heating system.

[0042] The reservoir heat exchanger **230** may pass entirely through the gas channel **255**, so that it functions as a gas-to-liquid heat exchanger. The reservoir heat exchanger **230** may remain entirely submerged within the water reservoir **255**, so that it functions as a liquid-to-liquid heat exchanger. As shown in FIGS. **2**A and **2**B, the heat exchanger **230** may pass partially through the gas channel **255** and partially through the water in the reservoir **255**. Further, the fluid in the heat exchanger **230** may flow in a direction counter to the flow of gas through the gas channel **255**, as shown, or alternatively may flow in the same direction as the flow of gas through the gas channel **255**.

[0043] Unlike traditional boiler heating systems, the return temperature of the water may not significantly impact the performance of the heater. For example, water returning to a pressurized boiler at a temperature below the condensing point of water, typically on the order of 140° F., could cause damage to the boiler. The reservoir heat exchanger **230** may be, for example, a water-to-water heat exchanger, thereby deriving its heat from the heated water in the reservoir chamber. Or, the reservoir heat exchanger **230** may be partially submerged below the water line **205**, so that the water in the heat exchanger derives its heat in part from the water in the reservoir chamber **225**, and in part from exposure to exhaust gas from the burner **210**.

[0044] While the water heater **200** may not operate under pressures in excess of one standard atmosphere, the water passing through the reservoir heat exchanger **230** may be under higher pressure than the water in the reservoir chamber **225**. For example, the water may be pressurized to force water through pipes upward to higher floors of the building from where the water heater **200** is located. Therefore, the system for pumping and circulating the hot water may be pressurized and thus subject to ASME codes. The circulation system may be constructed from heavier and more expensive materials to withstand the additional pressure. However, the pressurized part of the water heater **200** may represent a substantially smaller portion of the system than in prior art boilers, allowing the space heater to be constructed from less expensive materials, than materials used for a pressurized boiler.

[0045] Forced Hot Air System

[0046] FIG. **3** shows a second embodiment of an atmospheric space heater **300**. The second embodiment is similar to the first embodiment in that both have a burner **210** that vents heated exhaust gas through a burner vent **215** into a reservoir chamber **225**. An egress fan (not shown) draws exhaust from the burner **210** through the reservoir chamber **225**. The hot exhaust gas encounters water film on discs **260** partially submerged below a water line **205**, the discs **260** rotating on an axle **265**, driven by a motor **270**. The hot gas vaporizes the film of water on the first disc **260** closest to the burner vent **215**, cooling the exhaust gas and forming a mixture of exhaust gas and water vapor. As the mixture of exhaust gas and water vapor is drawn through the reservoir chamber **225**, the mixture encounters subsequent discs **260**, where some of the water vapor is cooled, causing some of the water vapor to re-condense and enter the reservoir **225** as hot water.

[0047] In the second embodiment, a vent **250** provides a conduit for hot water vapor to a hot air heater **380**. The hot water vapor passes through a vapor-to-air heat exchanger **390**, before exiting from a heat exchanger vent **350**. The air heated in the heat exchanger **390** may then be forced through hot air conduits, as with a conventional hot air furnace. As with the first embodiment, a domestic hot water coil **240** may be exposed to the heated water in the reservoir **225**.

[0048] Note that fewer discs **260** may be used for the second embodiment than the first embodiment, as the exhaust entering the air-to-vapor heat exchanger **390** may typically be hotter than the desirable temperature of gas emitted from the exhaust gas vent **250** (FIGS. **2**A and **2**B) in the first embodiment. Fewer discs **160** may therefore result in less cooling of the exhaust gas, and less heating of the water in the reservoir **225**.

[0049] Particulate Removal and Ash Storage

[0050] In addition to providing direct heating of water in the reservoir chamber instead of indirectly heating the water in the chamber through a heat exchanger, the first embodiment water heater **200** (FIGS. **2**A and **2**B) and the second embodiment space heater **300** (FIGS. **3**A and **3**B) may also remove particulates from the burner **210** exhaust gas, for example, in a pellet burning system. The burner exhaust gas may carry fly ash into the reservoir chamber **225**. As the exhaust gas encounters the water film on the discs **260**, as well as the water vapor produced as the exhaust gas evaporates the water film and the droplets of water introduced to the air by the rotating discs, the fly ash in the exhaust gas may combine with the water. As the water vapor re-condenses, as described above, the re-condensing water carries the fly ash into the water in the reservoir chamber. Over time, the ash may tend to settle to the bottom of the reservoir chamber **225**, as a layer of ash **207**. As the discs **260** rotate, any ash that may accumulate on the disc **260** surface above the water line **205** is carried into the water, thus cleaning the discs.

[0051] As mentioned previously, prior art systems have used water pumped through spray nozzles to remove particulates from burner exhaust gas. The pump systems require significantly more energy to operate than the amount of energy required to draw the air through the reservoir chamber **225** and to rotate the discs **260**. In addition, spray nozzles may become clogged with particulate matter, requiring either filtering of the water or cleaning of the nozzles.

[0052] In addition to accumulating fly ash in the reservoir chamber, heavy ash from the burner **210** may also be deposited in the reservoir chamber **225**, forming an ash-water slurry. For example, heavy ash may fall through a burner grate into a channel that deposits the heavy ash into the reservoir chamber **225**. The ash-water slurry may tend to settle to the bottom of the reservoir chamber **225**, as a layer of ash **207**. Further discussion of handling of spent fuel follows in the discussion of the agitating grates.

[0053] The reservoir chamber **225** may accumulate a significant amount of heavy ash in the ash-water slurry before maintenance is required. The reservoir may be maintained, for example, by annual replacement of the water in the reservoir chamber **225**. The ash-water slurry may then be processed to harvest chemicals for use in byproducts, for example, fertilizer, or a soil de-acidifying agent.

[0054] In other embodiments, the heavy ash may be collected without being introduced to the reservoir chamber **225**, for example, collecting heavy ash in a dry ash bin (not shown) attached to the burner **210**. In such an embodiment, replacement of water within the reservoir chamber may be relatively less frequent, or the water may be cycled through the reservoir chamber **225** and cleaned, for example, by filtering before re-introducing clean water into the reservoir chamber **225**. In an embodiment where ash is not collected within the reservoir chamber **225**, water in the reservoir chamber **225** may be circulated directly through an external heating system, for example, a radiator or a radiant floor heater, before being returned to the reservoir chamber **225**.

[0055] Water may occasionally be purged water from the reservoir chamber **225** as additional fluid accumulates, for example, through condensation of vapor introduced from the burner **210**.

[0056] Gravity Pellet Feeder

[0057] FIG. **4** shows a first embodiment of a gravity pellet feeder **400**, also referred to as an "angle of repose pelletized fuel feeder." The gravity pellet feeder is described further in the co-pending U.S. patent application Ser. No. 13/692,817 entitled "SOLID FUEL GRAVITY FEED COMBUSTION DEVICE, SYSTEM AND METHOD," which is incorporated by reference herein in its entirety. The first embodiment includes a pellet hopper (not shown) containing a plurality of pellets. The pellet hopper is positioned above a chute inlet **410** of a pellet feeder housing **415**. The size of the chute inlet **410** may be adjusted to regulate the flow rate of pellets. The pellets may flow through the chute leading to an outlet **420**, where pellets may accumulate in a pile on a feeder bottom **430** at an opening **440** exit the chute through an egress end **440** located, for example, at a burner **210** (FIG. **2**A). The chute inlet **410** may be closed, thereby, blocking an air path from the chute opening **440** through the inlet chute to the hopper.

[0058] The hopper may also include an airlock opening for adding pellets to the hopper. The airlock eliminates a possible air path through the pellet feed path. During normal operation, the airlock may be sealed shut, to prevent a fire backburn up from a pellet burner (not shown) through the chute **410** and into the hopper. The chute outlet may be positioned adjacent to a burner grate (not shown), so that excess pellets spill onto the burner grate to be conveyed to the pellet burner. Alternatively, the chute bottom **430** may incorporate a burner grate.

[0059] A pellet pile **450** forms upon the bottom **430**, with the surface of the pile **450** forming at approximately the angle of repose for the feed pellets. The angle of repose for wood pellet feed is typically in the range of 30 to 35 degrees, depending upon the specific geometry and mass of the pellets. Therefore the pellets may continue to flow through the chute until the pellet pile **450** grows to reach the height of the opening top **445**. Thereupon the flow of pellets ceases, until such pellets in the pellet pile **450** are removed or burned away, thereby lowering the pile **450** and allowing further pellets to flow from the hopper through the chute inlet **410**. In this way the flow of pellets is regulated by the geometry of the feeder **400** and the burn rate or removal rate of the pellets.

[0060] While the inlet **410** of the pellet feeder **400** is shown as rectangular in shape, there is no objection to the inlet **410** and/or housing **415** having other shapes, for example, circular. Similarly, while the pellet feeder opening **440** is shown to substantially expose the pellet pile **450**, there is no objection to a smaller opening **440** that substantially covers the pellet pile **450**, providing only enough space above the chute bottom **430** to facilitate removal of pellets from the pellet pile **150**.

[0061] In an alternative embodiment where the bottom **430** incorporates a burner grate, as pellets are burned away and the ash is removed, the pile **450** drops and additional pellets flow through the chute **410** to replace them, until the pile again rises to the level of the opening top **445**. The burner may be incorporate an updraft burner, where flames are drawn upward from the burner grate, or a downdraft burner, where flames are drawn downward through the bottom of the burner grate, for example, by an impelled air flow. For a larger pellet pile, the chute opening top **445** may be positioned relatively higher from the bottom **430**. For a smaller pellet pile, the chute opening top **445** may be positioned closer to the bottom **430**. In this way, the rate and volume of the pellet flow may be adjusted.

[0062] Simplified Agitating Grate

[0063] A solid fuel burner may include a permeated burner grate, such that fuel may burn upon the grate while allowing flow through ventilation for combustion. As solid fuel, for example, coal or wood pellets, burns on the surface of the burner grate, ash from spent fuel may accumulate upon the surface of the burner grate. Accumulation of spent fuel may both block the airflow in the burner required to burn the fuel, and may physically inhibit fresh fuel from entering the burner. Spent fuel ash may fall through the burner grate to be collected below. By moving or agitating the grate, ash may be broken into pieces small enough to fall through holes in the grate to a spent fuel collection area below the grate.

[0064] FIG. **5** shows three views of a first embodiment of a simplified agitating grate **500**. The simplified agitating grate is described further in the co-pending U.S. patent application Ser. No. 13/692,233 entitled "A MOVING GRATE DEVICE, METHOD, AND SYSTEM FOR COMBUSTION," which is incorporated by reference herein in its entirety. FIG. **5**A shows the grate substantially as assembled. The grate **500** of the first embodiment has a plurality of fixed grate member **510**, and a plurality of moving grate elements **520**. The grate members **510** and **520** have a flame side surface that supports the solid fuel while it is combusting, and a bottom side, oriented substantially opposite the flame side. The moving grate elements **520** may have one or more air channels **550** cut into them, extending through the flame side surface to the bottom side. The air channels **550** may provide a conduit for air to be drawn through the burner **210** (FIG. **2**A) to the burning solid fuel, and the air channels **550** may also provide an outlet for hard ash to fall through after the solid fuel is spent.

[0065] The grate elements **510** and **520** may be supported by one or more substantially horizontal support rods (not shown). A support rod may pass through a grate aperture **525** in the fixed grate element **510**, and may similarly pass through a slide aperture **560** (FIG. **5**B) in a movable grate element **520**, or a movable grate element support rod aperture **527** (FIG. **5**B). The support rod holds the fixed grate elements **510** in place, while allowing limited motion of the movable grate elements **520**. The inner diameter of grate aperture **525** is substantially equal to the outer diameter of a support rod (not shown), so that the support rod may support a fixed grate element **510** with minimal movement in a plane orthogonal to the grate aperture **525**. In contrast, turning to FIG. **5**B, the slide aperture **560** and movable grate element support rod aperture **527** are substantially larger than the outer diameter of a support rod, allowing limited movement in the plane orthogonal to the slide aperture **560** and movable grate element support rod aperture **527**.

[0066] The movable grate element **520** has a cam aperture **570**. In the first implementation of a simplified agitating grate **500** the cam aperture **570** is located toward an end of the movable grate element **520**. However, there is no objection to placement of the cam aperture **570** in other locations along the length of the movable grate element **520**.

[0067] FIG. **5**C shows an isolated view of a cam shaft assembly **590**. The cam shaft assembly includes two bearings **540**, a cam shaft **530** passing through the bearings **540**, and a plurality of cams **535** disposed along the cam shaft **530**. A cam **535** may be, for example, circular, oval, elliptical, or other similar shapes. Each cam **535** is offset from a center axis of the cam shaft **530**, so that the cam **535** wobbles when the cam shaft **530** rotates around its axis. Each cam **535** is associated with a movable grate element **520** (FIG. **5**B), the cam **535** being disposed within the cam aperture **570** (FIG. **5**B) of a movable grate element **520** (FIG. **5**B).

[0068] Returning to FIG. **5**B, when the cam shaft **530** is rotated, for example, by a motor (not shown), the movable grate element **520** associated with each cam **535** move in relation to the offset of the cam **535** from the cam shaft **530**. The movable grate element **520** is driven to move by the associated cam **535**, the range of motion of the movable grate element **520** restricted by the orientation of the slide aperture **560** of each movable grate element **520**. The support rod aperture **527** of the movable grate element **520** may be sized so the movable grate element **520** does not come in contact with the support rod (not shown) as the movable grate element **520** is moved by the associated cam **535**.

[0069] The motion of a movable grate element **520** is generally periodic, with the period equal to the time for the cam shaft **530** to make a single rotation. A first cam **535** may be oriented differently from a second cam **535**, so the motion of an associated first movable grate element **520** is different from the motion of a second movable grate element **520**. For example, if the first cam **535** and the second cam **535** are similarly shaped, a curve showing the motion of the first movable grate element **520** would differ from a curve showing the motion of the second movable grate element **520** only by the relative phases. The orientation of adjacent cams **535** may be adjusted to provide for variations in relative movements of adjacent grate elements. Similarly, cams **535** may be of different shapes and sizes to vary the movement cycles of individual grate elements. Note that while the discussion of the periodic movement of cams and grate elements assumes a constant rate of rotation of the cam shaft **530**, there is no objection to the cam shaft **530** rotating at an irregular rate.

[0070] The motion of the grate elements **520** need not be rapid, only enough to break up friable ash of spent solid fuel. The speed the rotating camshaft may be relatively low, for example, on the order of one rotation every 5-10 seconds. Faster or slower rotations speeds are also possible. Similarly, the grate elements may not need to be in continuous operation. For example, the grate may generally remain stationary and be periodically activated for short time intervals to remove ash and/or advance fresh fuel to the burner.

[0071] Once fragmented, the ash may fall through the air holes **550**, thereby creating room for fresh fuel on the grate **500**. The removal of spent fuel may be further assisted in downdraft burners, for example, burners where the airflow within the burner travels from the flame side of the grate downward through the air holes **550** to the bottom side. The downward airflow therefore encourages ash downward through the air holes **550**. Of course, there is no objection to application of the grate **500** with a traditional updraft burner.

[0072] In alternative embodiments, the fixed grate elements **510** may have air holes **550** formed in them. In further alternative embodiments, all of the grate elements may be movable grate elements **520**, with no fixed grate elements **510** used.

[0073] The ash that falls through the grate **450** may be collected in, for example, an ash bin. In the context of the first and second embodiments of the space heater, the ash may be transported to and stored in the reservoir chamber **225** (FIG. **2** and FIG. **3**). For example, the burner **210** may deposit ash into a moving water channel that empties into the reservoir chamber **225**, or into an air conduit such that moving air carries the ash into the reservoir chamber **225**. Alternatively, the burner **210** may be positioned substantially above the reservoir chamber **225** such that ash may fall directly into water in the reservoir chamber **225**.

[0074] System

[0075] A first exemplary embodiment of a pellet feeding system **600** is shown in FIG. **6**. Under the first embodiment system, fuel pellets **650** are stored in a remote hopper **610**, or other pellet repository. The pellets **650** may be conveyed from the hopper **610** by a mechanized conveyor **620**, for example, an auger driven tube, driven, for example, by a conveyer motor **622**, such that pellets **650** may drop down from the conveyor **620** into an angle of repose pellet feeder **640**, as described above, located within a pellet burner **660**. As shown by FIG. **6** the flow of pellets **650** between the conveyer **620** and the pellet feeder **640** may be further regulated, for example, with a secondary feeder motor **624** controlling an airlock **630**. The airlock **630** may be used between the auger **620** and the burner **660** for burn-back protection. The airlock **630** allows fuel to pass through while allowing only minimal air to pass through.

[0076] The pellets **650** accumulate in a pile in the feeder **640**, where the surface of the pile of pellets **650** is substantially at the angle of repose according to the geometry of the pellets **650**. The fuel pellets **650** are consumed within the burner **660**, upon a simplified agitating grate **670**, as described above. The simplified agitating grate is driven by a grate motor **626**. As pellets **650** are consumed they are replaced by additional pellets **450** as space becomes available in the feeder **400**. The mechanized conveyor **620** may typically only operate intermittently, for example, conveying pellets until the feeder **640** is filled above a high level sensor **662**, whereupon the mechanized conveyor is dormant until enough pellets **650** are consumed so the top of the pellet pile **650** falls below a low level sensor **664**.

[0077] As the pellets are burned upon the simplified agitating grate **670**, spent fuel, such as heavy ash, clinkers, is conveyed out of the burner **660**, for example, to an ash box (not shown) or other collection facility. Alternatively, the spent fuel may be conveyed to and collected within the reservoir chamber **681**, described below.

[0078] Hot gasses from the burner **660** are conveyed through a gas portal **662** to a reservoir chamber **681** of a water heater **680**. As described above, an axle **682** passes through the reservoir chamber **681**, and a plurality of heat exchange surfaces **683**, depicted here as discs with apertures passing through them, affixed to the axle **682**, mounted within an axle bearing **686**. The axle **682** is rotated by an axle drive motor

628, so the heat exchange surfaces **682** rotate within the reservoir chamber, as described above. Gasses cooled in the water heater **680** exit the water heater through the exhaust gas vent **684**. Water may be drawn from the water heater **680** via an outlet **685**.

[0079] Method

[0080] FIG. **7** is a flowchart of an exemplary method for heating water. It should be noted that any process descriptions or blocks in flow charts should be understood as representing modules, segments, portions of code, or steps that include one or more instructions for implementing specific logical functions in the process, and alternative implementations are included within the scope of the present invention in which functions may be executed out of order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved, as would be understood by those reasonably skilled in the art of the present invention.

[0081] The first exemplary method includes the step of providing a water reservoir chamber with a gas channel, an axle spanning the reservoir chamber, and a first disc and a second disc disposed upon the axle, as shown by block **710**. Hot gas is received into the reservoir chamber as shown by block **720**. The axle is rotated to partially coat the first disc and the second disc with a water film from the water reservoir, as shown by block **730**. Gas is drawn from the hot gas ingress portal into the gas channel, as shown by block **740**. Water film is vaporized on the first disc with the hot gas to produce water vapor, as shown by block **750**. Burner exhaust gas is expelled through the gas channel vent end, as shown by block **760**.

[0082] In summary, an atmospheric, low maintenance space heating method, system and apparatus is presented. Instead of bringing heated gas to water, the space heater brings water to heated gas using partially submerged rotating discs. Since the water heating occurs in an open, non-pressurized tank, lighter and less expensive materials may be used compared with systems that heat water under pressure.

[0083] Since the primary gas-to-water heat exchange occurs at atmospheric pressure, there is no possibility of the system housing being under pressure. Therefore, the system may not be subject to pressure vessel standards and/or codes. This may allow use of lighter and less costly materials that are in turn less costly and complex to handle and transport. The system may be used in a condensing mode, as all the materials in the heat exchanger may be made of materials not susceptible to corrosion when exposed to water and oxygen. With sufficiently cold return water, efficiencies approaching 100% may be realized.

[0084] The reservoir chamber may capture much of the fly ash produced by the combustion system, therefore reducing emissions. The incorporation of both a gravity feed burner and a moving grate and may handle fuels that traditional burners have difficulty using, such as agricultural pellets and high ash pellets.

[0085] The overall size of the system may be substantially smaller than traditional boilers producing a similar amount of heat which would be used only for the purpose of vaporizing water, thereby cooling the gas enough to then be used in a gas-to-air heat exchanger for space heating or process heating with air. The system may enjoy high efficiencies when used in a condensing-mode, thereby providing a highly efficient hot air heating system (furnace).

[0086] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. An atmospheric water heater connected to a burner with an exhaust gas portal, comprising;

a first heat exchanger comprising:

a reservoir chamber comprising a water reservoir and a gas channel in contact with the water reservoir, the gas channel further comprising a burner side and an egress side, the egress side disposed substantially opposite the burner side, the burner exhaust gas portal in communication with the reservoir chamber gas channel burner side;

a rotatable axle disposed within the gas channel, at least partially spanning the reservoir chamber gas channel from the burner side to the egress side; and

a plurality of spaced discs disposed upon the axle configured to rotate in rigid accompaniment with the axle, the axle disposed within the reservoir chamber such that the plurality of discs are partially submerged in the water reservoir and partially within the air chamber; and

a second heat exchanger.

2. The atmospheric water heater of claim **1**, further comprising:

a driver configured to rotates the axle; and

a reservoir chamber egress impeller in communication with the reservoir chamber gas channel egress side.

3. The atmospheric water heater of claim **1**, wherein said second heat exchanger comprises a water-to-fluid heat exchanger, the water-to-fluid heat exchanger comprising a fluid conduit disposed at least partially within the water reservoir.

4. The atmospheric water heater of claim **1**, wherein said second heat exchanger comprises a hot water coil disposed within the water reservoir.

5. The atmospheric water heater of claim **1**, wherein said second heat exchanger comprises a vapor-to-air heat exchanger, the vapor-to-air heat exchanger attached to the reservoir chamber gas channel egress side.

6. The atmospheric water heater of claim **1**, wherein the burner is a solid fuel burner.

7. The atmospheric water heater of claim **2**, wherein the driver is further configured to drive the reservoir chamber egress impeller.

8. A method for heating water with hot gas from a burner, comprising the steps of:

providing a water heater comprising:

a reservoir chamber comprising a water reservoir and a gas channel above the water reservoir, wherein the gas channel is in direct physical contact with the water reservoir, the gas channel comprising a hot gas ingress end, and a vent end;

a rotatable axle at least partially spanning the reservoir chamber, the axle disposed substantially through the gas channel;

a first disc disposed upon the axle, the first disc disposed partially submerged in the water reservoir, the first disc configured to rotate in rigid conformity with the axle, the first disc disposed substantially at the hot gas ingress end of the gas channel; and a second disc disposed upon the axle, the second disc disposed partially submerged in the water reservoir, the second disc configured to rotate in rigid conformity with the axle, the second disc disposed substantially at the vent end of the axle;

receiving hot gas into the hot gas ingress portal;

rotating the axle, thereby partially coating the first disc and the second disc with a water film from the water reservoir,

drawing gas from the hot gas ingress portal through the gas channel; and

expelling exhaust gas through the gas channel vent end.

9. The method of claim **8**, further comprising the steps of:

vaporizing the water film on the first disc with the hot gas, thereby producing water vapor; and

conveying the water vapor through the gas channel toward the vent end of the axle.

10. The method of claim **9**, further comprising the steps of:

introducing the water vapor to the second disc; and

condensing the water vapor upon the second disc.

11. The method of claim **10**, further comprising the step of passing liquid through a water-to-liquid heat exchanger disposed at least partially within the reservoir chamber.

12. The method of claim **8**, further comprising the step of passing water through a domestic hot water coil disposed within the reservoir chamber.

13. The method of claim **8**, further comprising the step of conveying water vapor from the gas channel into a water vapor-to-air heat exchanger.

14. The method of claim **9**, further comprising the steps of:

drawing water out of the reservoir chamber into an external radiator; and

returning water from the external radiator to the reservoir chamber.

15. The method of claim **8**, further comprising the step of purging excess water from the water reservoir.

16. The method of claim **8**, further comprising the steps of:

collecting heavy ash in the water reservoir as a water-ash slurry, and

replacing water-ash slurry in the water reservoir with fresh water.

17. A pelletized fuel burning space heating system comprising:

a pelletized fuel burner comprising:

an angle of repose pelletized fuel feeder; and

an agitating burner grate configured to receive pellets from the fuel feeder; and

an atmospheric water heater comprising:

a reservoir chamber partially filled with water configured to receive exhaust gas from the fuel burner; and

an axle comprising a plurality of partially submerged spaced discs rotatably disposed within the reservoir chamber.

18. The system of claim **17**, further comprising a water-to-water heat exchanger disposed within the reservoir chamber.

19. The system of claim **17**, further comprising a vapor-to-air heat exchanger comprising an ingress opening in communication with the egress vent.

20. An atmospheric water heater, comprising;

a water tank;

a solid fuel burner configured to transfer heat from the burner to the water tank; and

means for transferring spent fuel from the fuel burner into the water tank.

* * * * *