(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 March 2012 (01.03.2012)

PCT

(10) International Publication Number
WO 2012/026950 A1

(51) International Patent Classification:
F26B 9/02 (2006.01) *A24B 3/04* (2006.01)
A24B 1/02 (2006.01) *F26B 3/02* (2006.01)

(21) International Application Number:
PCT/US2010/053395

(22) International Filing Date:
20 October 2010 (20.10.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/402,379 26 August 2010 (26.08.2010) US
61/387,777 29 September 2010 (29.09.2010) US

(72) Inventor; and
(71) Applicant : SCOTT, Peter [CA/CA]; 525 Campbellton Rd, Montague, PEI COA 1 R0 (CA).

(74) Agents: TARLETON, Russell, E. et al.; Seed Intellectual Property Law Group PLLC, Suite 5400, 701 Fifth Avenue, Seattle, WA 98104-7064 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report (Art. 21(3))*

(54) Title: NATURAL DRAFT CURING SYSTEM

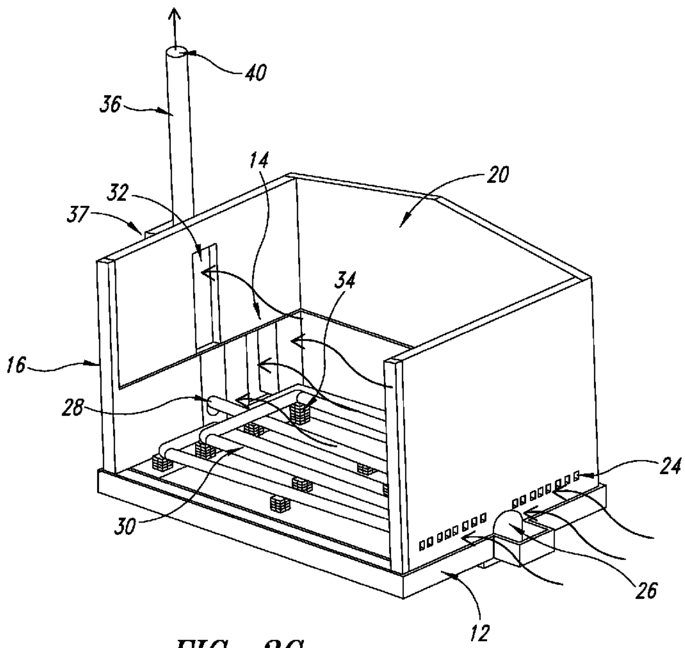

FIG. 3C

(57) Abstract: A natural draft curing system for curing objects is provided, the system including a building having a roof and a plurality of walls; a source of heat having a chimney system that conveys hot gases and exhaust from the heat source to an exterior of the building and creates a negative pressure in the building interior; a system of convective pipes in the interior of the building coupled to a the chimney system that circulate hot flue gases; a plurality of vents that admit ambient air drawn in to the interior of the building by the negative pressure and direct the ambient air over the system of convective pipes to heat the ambient air; and a structure to hold the objects to be cured in the interior of the building.

WO 2012/026950 A1

NATURAL DRAFT CURING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the priority benefits of US provisional patent application serial number 61/402,379, filed August 26, 2010, and U.S. provisional patent application serial number 61/387,777, filed September 29, 2010.

BACKGROUND

Technical Field

The present disclosure pertains to the curing of organic materials and, more particularly, to a system of curing materials such as tobacco leaves that reduces the use of wood or coal and provides environmental benefits such as reducing greenhouse gases and deforestation.

Description of the Related Art

The curing of Flue Cured Virginia or (FCV) tobacco is an energy intensive procedure due to the large amounts of moisture that must be removed from the freshly harvested leaves. For example, a typical tobacco barn containing 20,000 pounds of green tobacco leaves requires the removal of up to 17,000 pounds of water. Modern and fuel efficient curing systems are common in the developed world, and a number of patents exist for bulk curing systems that use forced air and complex heat recovery systems (for example, U.S. patent no. 6,742,284). In the developing world, however, even though some of these modern methods are available, the majority of tobacco is still cured with archaic and inefficient systems.

In developing countries, tobacco is cured either by large commercial farmers or by small Holder Farmers.

Small Holder Farmers (those who cultivate approximately 1-5 hectares of tobacco) cure tobacco in simple, unsealed sheds made from brick, sticks, and mud. Tobacco is placed inside the shed and a small fire is built inside a rudimentary brick furnace. The furnace is connected to fireboxes that are made from brick and metal, with a brick chimney. The firebox lengths range from 3 to 9 m. The roof of the structure is made from thatch or corrugated steel. Small vents are placed in the four corners of the structure, through which air is naturally drawn in and heated, which collects moisture from the leaves before it exits through a small crack between the ceiling and the top walls. The structures are generally poorly built, prone to destruction by fire, and make it difficult to control the curing process. Additionally, the systems are extremely inefficient—specific fuel consumption ranges up to 15 KG of wood per KG of dry tobacco produced (15:1). Existing modern curing methods are beyond the financial reach of almost all small holder farmers.

Two general categories of curing systems are available for commercial farmers (farmers with more than 5 hectares of tobacco under cultivation) in the developing world. The first is the previously mentioned forced air systems, such as the bulk curers. The second category of curing system is non-forced air systems. These systems are similar to the small holder system (described above), but with several changes. They are larger and utilize a more complex furnace in conjunction with flue pipes instead of fireboxes. Airflow is controlled both at the inlet (in the bottom four corners of the structure) and the outlet (at the top of the structure). These systems are extremely inefficient (specific fuel consumption ranging from 5:1 up to 10:1), but are still popular because they are relatively cheap to construct and manage, and no low cost alternatives exist.

These systems face a number of challenges and shortcomings. For example, because air is vented through the ceiling during most of the curing process, it is not possible to insulate the ceiling. This causes significant losses and forces the furnace to run at higher power levels, which increases the risks of barn fires and/or drying the leaf before it is cured (a.k.a. ‘fixing green’). The conventional curing systems are difficult and complicated to manage and therefore are often beyond the skill level of the unskilled laborers who manage the barns. The end result is that vents and doors are often not closed or opened at the correct times, which leads to increased fuel consumption and a reduction in the quality and value of the finished leaf.

BRIEF SUMMARY

The present disclosure relates generally to a system and method for more economically and efficiently drying a moisture containing material and is particularly applicable to the curing and drying of tobacco. Although specifically designed for tobacco, it is contemplated that the principles taught herein can also be applied to dry other products, including a wide variety of agricultural and food products.

In accordance with one embodiment of the present disclosure, a natural draft curing system for curing objects is provided. The system includes a building having a roof and a plurality of walls with at least one wall having an opening to provide egress in to and out of an interior of the building; a source of heat associated with the interior of the building, the source of heat having a chimney system that conveys hot gases and exhaust from the heat source to an exterior of the building, the chimney system having a first chimney pipe of a first diameter and a second chimney pipe of a second diameter that is greater than the first diameter to create a negative pressure in the interior of the building when hot flue gasses exit the first chimney pipe; a system of convective pipes in the interior of the building coupled to a the chimney system that circulate hot flue gases and provide heat to the interior of the building; a plurality of vents in at least one wall of the plurality of walls that admit ambient air drawn in to the interior of the building by the negative pressure created in the interior by the chimney system, the vents structured to direct the ambient air over the system of convective pipes to heat the ambient air; and a structure to hold the objects to be cured in the interior of the building.

In accordance with another embodiment of the present disclosure, a heating system for the interior of a structure is provided. The heating system includes a source of heat; a system of convective pipes in the interior of the structure; an exhaust system having a first exhaust pipe connected to the source of heat and to the system of convective pipes, and a second exhaust pipe surrounding the first exhaust pipe and extending upward past a top of the first exhaust pipe, the second exhaust pipe in fluid communication with the interior of the structure; and a vent system in the structure in fluid communication with the interior of the structure and with ambient air exterior to the structure.

In accordance with another aspect of the present disclosure, the heating system includes a control system coupled to the vent system.

In accordance with a further aspect of the present disclosure, the system of convective pipes is coupled to the first exhaust pipe and the vent system is positioned to direct ambient air over the convective pipes. Ideally, the convective pipes are positioned adjacent a floor of the structure, and the vent system comprises at least one vent formed in a wall of the structure adjacent the floor and opposite a wall on which the exhaust system is formed.

In accordance with yet a another aspect of the present disclosure, the system of convective pipes is connected to the source of heat and is structured to conduct combustion gases from the source of heat to the first exhaust pipe and to radiate heat to the interior of the structure. Ideally the source of heat is a wood burning or fan-assisted coal burning furnace. Other forms of biomass, such as compressed or non compressed agricultural waste products (rice husks, coffee husks, bagasse, etc.) can also be used as a fuel source .

In accordance with another aspect of the present disclosure, a natural draft curing system for curing objects is disclosed. The system includes a building having a roof and a plurality of walls supporting the roof; a source of heat associated with the interior of the building, the source of heat having a chimney system that conveys hot gases and exhaust from the heat source to an exterior of the building, the chimney system having a first chimney pipe of a first diameter and a second chimney pipe of a second diameter that is greater than the first diameter to create a negative pressure in the interior of the building when hot flue gasses exit the first chimney pipe; a system of convective pipes in the interior of the building coupled to the chimney system that circulate hot flue gases and provide heat to the interior of the building; a plurality of vents in at least one wall of the plurality of walls that admit ambient air drawn in to the interior of the building by the negative pressure created in the interior by the chimney system, the vents structured to direct the ambient air over the system of convective pipes to heat the ambient air; and a structure to hold the objects to be cured in the interior of the building over the system of convective pipes. Ideally the system includes a control system coupled to the vent system.

In accordance with another aspect of the present disclosure, the system of convective pipes is coupled to the first exhaust pipe and the vent system is positioned to direct ambient air over the convective pipes. Preferably, the convective pipes are positioned adjacent a floor of the structure, and the vent system comprises at least one vent formed in a wall of the structure adjacent the floor and opposite a wall on which the exhaust system is formed.

In accordance with still yet a further aspect of the present disclosure, the system of convective pipes is connected to the source of heat and is structured to conduct combustion gases from the source of heat to the first exhaust pipe and to radiate heat to the interior of the structure.

In accordance with another aspect of the present disclosure, a method for curing objects using a natural draft system according with any of the foregoing embodiments is provided. For example, the natural draft system includes a building having a roof and a plurality of walls supporting the roof; a furnace associated with the interior of the building, the furnace having a chimney system that conveys hot gases and exhaust from the furnace to an exterior of the building, the chimney system having a first chimney pipe of a first diameter and a second chimney pipe of a second diameter that is greater than the first diameter to create a negative pressure in the interior of the building when hot flue gasses exit the first chimney pipe; a system of convective pipes in the interior of the building coupled to the chimney system that circulate hot flue gases and provide heat to the interior of the building; at least one vent in at least one wall of the plurality of walls that admits ambient air drawn in to the interior of the building by the negative pressure created in the interior by the chimney system, the at least one vent structured to direct the ambient air over the system of convective pipes to heat the ambient air; and a structure to hold the objects to be cured in the interior of the building over the system of convective pipes. The method includes providing fuel to the furnace to generate hot flue gases from a combustion of the fuel; having the hot flue gases pass through the system of convective pipes to generate heat to the interior of the building, then having the hot flue gases pass through the first chimney pipe and then the second chimney pipe to create a negative air pressure in the interior of the building relative to ambient air pressure; allowing ambient air to enter the interior of the building through the at least one vent in response to the negative interior air pressure.

Preferably, the method includes controlling the at least one vent to selectively open and close the at least one vent in response to conditions in the interior of the building.

In accordance with another aspect of the method, the system of convective pipes is coupled to the first exhaust pipe and the at least one vent is positioned in the at least one wall, and the method includes directing ambient air over the system of convective pipes.

In accordance with another aspect of the method, the convective pipes are positioned adjacent a floor of the structure, and the at least one vent is formed in one wall of the structure adjacent the floor and opposite a wall on which the exhaust system is formed, and the method includes directing the ambient air over the convective pipes in a direction away from the at least one vent and towards the wall on which the exhaust system is formed.

Ideally the method includes providing one of wood, coal, or other form of biomass as the fuel for the furnace. In addition, the method has an initial step of placing the objects to be dried on the support structure in the interior of the building.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1A is an isometric exterior view of a traditional small holder tobacco curing shed;

Figure 1B is an isometric cutaway perspective of the internal components of a traditional small holder tobacco curing shed showing the furnace and the brick and metal heat exchanger inside the curing shed;

Figure 2A is an external elevation view of a conventional commercial tobacco curing shed. It shows a furnace, air intake, and an external single chimney common to conventional barns;

Figure 2B is an internal plan view of a conventional commercial barn showing the Y furnace, flue pipes, and the chimney positioned above the furnace;

Figure 3A is a mechanical drawing of an external isometric view of a first embodiment of a dryer (18,000 KG capacity, wood powered) formed in accordance with the present disclosure (wood powered);

Figure 3B is a schematic drawing of an external isometric front view with cutaway of the dryer of Figure 3A;

Figure 3C is a schematic drawing of the external isometric front view with cutaway of the dryer of Figure 3B with the tier poles removed for clarity;

Figure 3D is a schematic drawing of an external isometric front view with cutaway of the dryer of Figure 3B (18,000 KG capacity wood powered iteration) with the tier poles and tobacco leaves added for illustrative purposes;

Figure 3E is a mechanical drawing and external isometric rear view of the dryer of Figure 3A;

Figure 3F is a schematic drawing of an external isometric rear view of the dryer of Figure 3A with the chimney sections partially cut away for illustrative purposes;

Figure 3G is an internal plan view of the furnace;

Figure 3H is a schematic drawing of an external isometric view of the dryer of Figure 3B with the vent doors shown in the open position whereas the furnace door is closed;

Figure 3I is a schematic drawing of an external isometric view of the dryer of Figure 3B with the vent doors and furnace door shown in a closed position;

Figure 3J is a schematic drawing of an internal isometric view of the dryer of Figure 3B in which the positioning of flue pipes and air vents is shown;

Figure 3K is an isometric front view of the furnace.

Figure 4A is a schematic drawing of an external isometric view of an alternative embodiment of the dryer of Figure 3A (18,000 KG capacity, coal powered with fan assist iteration) formed in accordance with the present disclosure;

Figure 4 B is an illustration of a coal furnace with fan assist for the embodiment of Figure 4A;

Figure 5A is a schematic drawing of an external isometric front view of an alternative embodiment of the dryer (3000 KG capacity, wood powered iteration) formed in accordance with the present disclosure; and

Figure 5B is a schematic drawing of an external isometric rear view of the embodiment of Figure 5B in which the chimney sections and a side wall are partially cutaway for illustrative purposes.

DETAILED DESCRIPTION

Building

In one embodiment, a drying system and a method for its use is provided, the drying system includes a building 10 having a drying chamber or container containing a product to be dried. Figure 3A shows the basic barn structure, generally indicated by the numeral 10, with front wall 11, side walls 13 and 15, rear wall 16, and a metal roof 17 that protects the interior, including a main curing chamber 20, from the elements. The volume of the main curing chamber 20 varies from 10 to 300 cubic meters depending on the quantity of tobacco to be cured. The front wall 11 contains air vents 24. The total number of the vents ranges from 8 vents for the 250 stick barn to 16 vents for the 1000 stick barn. The total cross-sectional area of the vent inlets 24 varies from 1200 cm^2 for a 250 stick rocket barn to 2400 cm^2 for a 1000 stick rocket barn. Each of the individual vents range from 10 cm tall x 10 cm wide for a 250 stick rocket barn to 15 cm tall x 10 cm wide for a 1000 stick rocket barn. The front air vents 24 are the only source of fresh air into the main curing chamber 20.

Referring to Figure 3B, the system includes the plurality of air inlet vents 24 for fresh air, a drying air pathway 19, a wood powered heat source 26, a heat exchanger 30, and a double chimney exhaust system 35 (described in more detail below in conjunction with Figure 3F). The system of the present disclosure offers major innovations not currently known in the art. The system provides a unique energy efficient method for ~~processsing~~ processing large quantities (up to 18,000 kg) of flue cured (FCV) tobacco that utilizes waste heat to develop a horizontal convective flow of drying air to remove moisture from the tobacco leaf without the use of an electrical fan.

As seen in Figure 3C, the system features one double outlet furnace 26 (Venturi 'Y' furnace) in conjunction with an exhaust system 35 that includes, in this embodiment, 25 to 70 meters of 25 to 30 cm diameter flue pipes 30 in the interior or main curing chamber 20 of the building 10. The furnace 26 and flue pipe system 30 is structured to provide heat to the tobacco and the inner barn environment 20. As seen in figure 3C, the convective flue pipe system 30 exits the main curing chamber 20, where it passes into a 30 cm diameter chimney 38 (shown in Figure 3F). Ideally the chimney 38 is enclosed on three sides and partially enclosed on a fourth side by a brick chimney structure 37, with inner volume ranging from 2 to 10 cubic meters, depending on the quantity of tobacco to be cured. After exiting the 30 cm diameter internal chimney 38, the hot flue gases pass into a 56 cm diameter external chimney 36. This causes the air temperature to rise inside of the external chimney 36, creating a pressure drop inside the external chimney 36 and in the interior 20 of the dryer building 10. This results in the pulling of air in through the plurality of air intake vents 24 along the front wall 11. The double chimney system 35 creates a powerful (1.6 m/s) convective flow of drying air through the tobacco leaves 39 and inner barn environment 20.

The system can be adapted for curing any quantity of tobacco from 0-18,000 kg. Three iterations of the Curing Barn have been constructed:

1. An 18,000 kg capacity wood powered system (designed for commercial farmers);

2. An 18,000 kg capacity coal powered system with fan assist furnace (designed for commercial farmers); and

3. A 4,000 kg capacity wood powered furnace (designed for small holder farmers) that utilizes either metal flue pipes or brick/metal fireboxes.

The design creates a high-quality product (44% increase in crop value for Malawian small holder tobacco farmers) while using significantly less fuel (up to 70% reduction in wood) as compared to traditional systems.

As seen in Figure 3D, the main curing chamber 20 holds the sticks of tobacco 21, which are supported on horizontal tier poles 22. The floor 23 of the structure is flush with the top of the foundation 12, and supports the 'Y' outlet furnace 26. The furnace 26 connects to flue pipes 30, which are supported by eleven brick supports 34, which vary in height from 10 cm – 40 cm. The length of the flue pipe heat exchanger varies from 20 m for a 250 stick barn up to 80 m for a 1000 stick barn. The rear wall 16, shown in Figure 3E, contains a door 18 and a rear wall opening 32 (shown in Figure 3F) that varies from 80 cm x 150 cm in size for a 250 stick barn up to 80 cm x 250 cm for 1000 stick barn.

Referring to Figure 3F, the flue pipe gases exit the furnace 26 and travel through the main curing chamber 20 via the system of convective flue pipes 30 in the exhaust system 35 and enter into a 30 cm diameter internal chimney 38. The internal chimney 38 is partially contained by the brick chimney 37 that varies in height, depending on the quantity of tobacco that is cured, from 2.5 m for a 250 stick barn to 4.5 m for a 1000 stick barn. The height of the internal chimney 38 varies from 3.6 m for a 250 stick rocket barn to 5.3 m for a 1000 stick rocket barn. After exiting the outlet 42 of the internal chimney 38, the gasses pass into the outer chimney 36. The outlet 42 for the internal chimney 38, is placed halfway up the height of the exterior chimney 36. The height of the exterior chimney 36 varies from 2 m for a 250 stick barn to 4.4

m for a 1000 stick barn. The rear wall opening 32 creates an air passageway between the outer exterior chimney 36 and the main curing chamber 20.

As seen in Figure 3J, the flue pipe length nearest to the air vents 24 should be placed so as to create a 20 cm horizontal gap 33 between the flue pipes lengths 30 and the air vents 24. The center point of the flue pipe nearest the air vent 24 should be flush with center vertical point of air vents 24.

The barn is insulated with a 15 cm thick layer of grass or other insulation in the ceiling 9 (Figure 3A), which prevents air losses through the roof 17. Referring to Figure 3C, the main curing chamber 20 is completely sealed from the outer environment except for the door 14, air vents 24, rear wall opening 32, and the outlet 40 of the outer chimney 38.

Heating

The present disclosure features either a wood (or other biomass powered) furnace or a coal powered furnace for heating. The internal dimensions of the furnace feed chamber are 37 cm x 37 cm with a length varying from 1- 3 m 47. The opening of the conventional furnace is 60 cm x 60 cm 8. The smaller rocket barn furnace 26 is made possible due to its ability to operate at lower wattage/fuel consumption than the conventional furnace. As seen in Figure 3G, the furnace also features a high-strength water bonded v-slot 46, which lies at the bottom of the furnace feed chamber 47.

Referring to Figure 3H, the furnace features a metal door 27 that is always closed except during loading of firewood. All combustion air enters the feed chamber and combustion zone from under the v-slot 46. As the wood burns, ash falls through the v-slot and into the ash pit 29. As it is possible for some charcoal and ash to be trapped in the v-slot, a 5 cm x 37 cm T–slot opening 48 shown in Figure 3G is constructed ahead of the v-slot 46 to provide sufficient combustion air during periods of blockage in the v-slot. After leaving the furnace, the hot flue gases travel out through the ‘Y’ outlet 49 in Figure 3K, and into the flue pipes. The rocket barn features 30 – 50% more flue pipe surface area as compared to the conventional flue pipe system seen in Figure 2B. Surface temperatures of the flue pipes range from 0-250°C. The hot flue gases cool from a maximum of 800°C at the furnace outlet to a maximum of 150°C when, referring to Figure 3F, they pass out of the flue pipe outlet 28 on the back wall 16 and into the internal chimney 38, and then the outer chimney 36.

As previously mentioned, the rocket barn furnace 26 runs at lower power levels than do the conventional systems. This translates into lower surface temperatures, immediately adjacent the furnace, for the flue pipes, which reduces the possibility of barn fires and 'fixing green' and increases the quality of the tobacco.

Control system

As seen in Figures 3B-3D, air vents 24 allow fresh, relatively dry, atmospheric air to be drawn into the curing chamber 20 where tobacco is hung on sticks 21 that are placed on horizontal tier poles 22. In Figure 3D, the furnace 26 is loaded with firewood, and hot flue gases pass through the flue pipes 30. The gases produced in the furnace 26 travel through the flue pipes 30 and heat the curing chamber 20.

Referring to Figure 3F, hot flue gases are vented into the inner smaller diameter (30 cm) chimney 38. Upon exiting through the outlet 42, they enter into an outer larger diameter (56 cm) chimney 36. The outer chimney 36 heats up, which causes a pressure drop. Because the outer chimney 36 is connected to the main curing chamber 20 through the rear wall opening 32, the pressure drop draws ambient air into the curing chamber 20 through the front wall air vents 24.

As seen in Figure 3D, the atmospheric air follows the path 19 above flue pipes 30 and is heated. Moisture from the tobacco leaves is transferred into the heated air. This design eliminates the need for an electrical fan to move moisture out of the barn and is more efficient and easier to manage than venting air through an outlet in the roof as seen in Figure 2A of the conventional system. As seen in Figures 3H and 3I, airflow into the main curing chamber is controlled by two vent doors 25 that cover the eight through sixteen air intake vents 24. The temperature of the barn is regulated by the quantity of wood that is placed in the feed chamber 47.

Operation

As seen in Figure 3D, tobacco is strung on wood or bamboo sticks 21 and laid out on horizontal tier poles 22. The curing operation begins when the fire is lit, and is carried out according to industry standard practices, including yellowing, fixing, leaf drying, stem drying, and conditioning of the tobacco. Unlike conventional barns, depicted in Figure 2A, which require precise and constant manipulation of the vent covers at both the four corner air inlets 7 and roof outlet 6, the rocket barn has only two air flow intake controls. Referring to Figure 3H, during yellowing, fixing, and leaf drying, the two air intake vent doors 25 are left in the open position. Once the leaf or lamina is dry, the two air vent doors are closed for the drying of the mid rib, as seen in Figure 3I. The vent doors remain closed until the end of the drying process. The vent doors 25 are closed over the vents 24, stopping airflow in one simple action, unlike the inlet and outlet vent controls of the conventional barns. The vent covers are held open or closed by wire latches that are connected to anchor bolts which are sunk into the barn wall. A number of closure configurations can be constructed to manipulate the vent covers. The furnace door 27 is closed throughout the process except when wood is added. During the daytime conditioning phase, the vent doors 25 remain closed. During the nighttime conditioning phase, the vent doors are open. It is possible to connect the vent cover 25 to a computerized thermostat and relative humidity sensor to allow for automated control of air entering the main curing chamber 20.

Other iterations of the present design

Coal powered/fan assist

A variation of the present disclosure, which is also suitable for curing 0 - 18,000 KG of tobacco, has been designed to burn coal instead of firewood, and is illustrated in Figure 4A. The coal is placed inside of a 37 cm x

37 cm furnace 26 with a length varying from 1- 3 m. As seen in Figure 4B, inside the furnace, at the bottom of the feed chamber are two cast-iron plates 50, which have a width and length of 35 cm x 35 cm. Each plate features twenty-five 2 cm openings 52. The coal is fed by hand on top of the plates. Under the cast-iron plates is an ash collection area and air intake area 29, to which a 250 W fan 31 is connected. The fan supplies a continuous turbulent stream of air through the 2 cm openings in the cast-iron plates and then into the combustion zone 56. As the fan is run continuously throughout the curing process, no use of a thermostat is required to switch the fan off and on during the curing cycle . If the barn is run in parallel with other coal powered barns ,the single fan can be removed and the forced air can be provided to all of the barns simultaneously by a single higher power (>500W) fan. The furnace door 27 is made from cast iron due to the high temperatures associated with burning coal. Seen in Figure 4B is an airtight cast-iron door 54 that is placed in front of the ash collection area 29. Although a fan is used to increase combustion efficiency and transport the hot flue gases through the flue pipe system, no fan is used to move moisture in or out of the drying environment. With the exception of the different furnace, all other aspects of the barn are the same as the wood powered version described above.

Lower-Cost Iteration for Small Holder Farmers

A third iteration, seen in Figures 5A and 5B, has been created for small holder farmers that utilizes a single outlet furnace 60 and lower-cost brick and metal fire boxes 62. The internal dimensions of the furnace are 37 by 37 cm at the inlet and 37 by 30 cm at the outlet. The internal dimensions of the fire boxes are 30 cm x 30 cm. In total, the firebox length ranges from 12 to and including 18 m.

The various embodiments described above can be combined to provide further embodiments. All of the U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet are incorporated herein by reference, in their entirety. Aspects of the embodiments can be modified, if necessary to employ concepts of the various patents, applications and publications to provide yet further embodiments.

These and other changes can be made to the embodiments in light of the above-detailed description. In general, in the following claims, the terms used should not be construed to limit the claims to the specific embodiments disclosed in the specification and the claims, but should be construed to include all possible embodiments along with the full scope of equivalents to which such claims are entitled. Accordingly, the claims are not limited by the disclosure.

CLAIMS

1. A heating system for the interior of a structure, comprising:

a source of heat;

a system of convective pipes in the interior of the structure;

an exhaust system having a first exhaust pipe connected to the source of heat and to the system of convective pipes, and a second exhaust pipe surrounding the first exhaust pipe and extending upward past a top of the first exhaust pipe, the second exhaust pipe in fluid communication with the interior of the structure; and

a vent system in the structure in fluid communication with the interior of the structure and with ambient air exterior to the structure.

2. The heating system of claim 1 comprising a control system coupled to the vent system.

3. The heating system of claim 1, wherein the system of convective pipes is coupled to the first exhaust pipe and the vent system is positioned to direct ambient air over the convective pipes.

4. The heating system of claim 3, wherein the convective pipes are positioned adjacent a floor of the structure, and the vent system comprises at least one vent formed in a wall of the structure adjacent the floor and opposite a wall on which the exhaust system is formed.

5. The heating system of claim 4, wherein the system of convective pipes is connected to the source of heat and is structured to conduct combustion gases from the source of heat to the first exhaust pipe and to radiate heat to the interior of the structure.

6. The heating system of claim 1 wherein the source of heat is a wood or other form of biomass fueled furnace or coal burning furnace.

7. The heating system of claim 6, wherein the source of heat is a fan-assisted coal burning furnace.

8. A natural draft curing system for curing objects, comprising:

a building having a roof and a plurality of walls supporting the roof;

a source of heat associated with the interior of the building, the source of heat having a chimney system that conveys hot gases and exhaust from the heat source to an exterior of the building, the chimney system having a first chimney pipe of a first diameter and a second chimney pipe of a second diameter that is greater than the first diameter to create a negative pressure in the interior of the building when hot flue gasses exit the first chimney pipe;

a system of convective pipes in the interior of the building coupled to the chimney system that circulate hot flue gases and provide heat to the interior of the building;

a plurality of vents in at least one wall of the plurality of walls that admit ambient air drawn in to the interior of the building by the negative pressure created in the interior by the chimney system, the vents structured to direct the ambient air over the system of convective pipes to heat the ambient air; and

a structure to hold the objects to be cured in the interior of the building over the system of convective pipes.

9. The system of claim 8 comprising a control system coupled to the vent system.

10. The system of claim 9, wherein the system of convective pipes is coupled to the first exhaust pipe and the vent system is positioned to direct ambient air over the convective pipes.

11. The system of claim 10, wherein the convective pipes are positioned adjacent a floor of the structure, and the vent system comprises at least one vent formed in a wall of the structure adjacent the floor and opposite a wall on which the exhaust system is formed.

12. The system of claim 11, wherein the system of convective pipes is connected to the source of heat and is structured to conduct combustion gases from the source of heat to the first exhaust pipe and to radiate heat to the interior of the structure.

13. The system of claim 12 wherein the source of heat is a wood burning or coal burning furnace.

14. The system of claim 12, wherein the source of heat is a fan-assisted coal burning furnace.

15. A method for curing objects using a natural draft system, the natural draft system having a building having a roof and a plurality of walls supporting the roof; a furnace associated with the interior of the building, the furnace having a chimney system that conveys hot gases and exhaust from the furnace to an exterior of the building, the chimney system having a first chimney pipe of a first diameter and a second chimney pipe of a second diameter that is greater than the first diameter to create a negative pressure in the interior of the building when hot flue gasses exit the first chimney pipe; a system of convective pipes in the interior of the building coupled to the chimney system that circulate hot flue gases and provide heat to the interior of the building; at least one vent in at least one wall of the plurality of walls that admits ambient air

drawn in to the interior of the building by the negative pressure created in the interior by the chimney system, the at least one vent structured to direct the ambient air over the system of convective pipes to heat the ambient air; and a structure to hold the objects to be cured in the interior of the building over the system of convective pipes, the method comprising:

providing fuel to the furnace to generate hot flue gases from a combustion of the fuel;

having the hot flue gases pass through the system of convective pipes to generate heat to the interior of the building, then having the hot flue gases pass through the first chimney pipe and then the second chimney pipe to create a negative air pressure in the interior of the building relative to ambient air pressure;

allowing ambient air to enter the interior of the building through the at least one vent in response to the negative interior air pressure.

16. The method of claim 15 comprising controlling the at least one vent to selectively open and close the at least one vent in response to conditions in the interior of the building.

17. The method of claim 15, wherein the system of convective pipes is coupled to the first exhaust pipe and the at least one vent is positioned in the at least one wall, the method comprising directing ambient air over the system of convective pipes.

18. The method of claim 17, wherein the convective pipes are positioned adjacent a floor of the structure, and the at least one vent is formed in one wall of the structure adjacent the floor and opposite a wall on which the exhaust system is formed, the method comprising directing the ambient air over the convective pipes in a direction away from the at least one vent and towards the wall on which the exhaust system is formed.

19. The method of claim 15, comprising providing one of wood and coal as the fuel for the furnace.

20. The method of claim 15, comprising initially placing the objects to be dried on the support structure in the interior of the building.

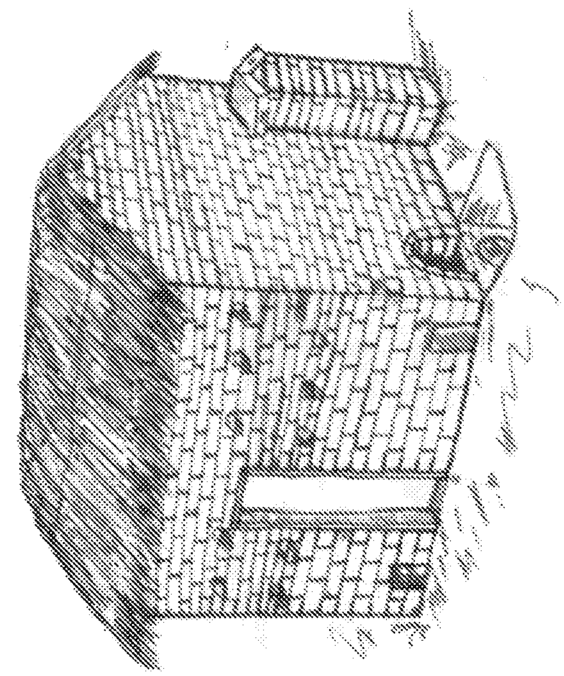

FIG. 1A

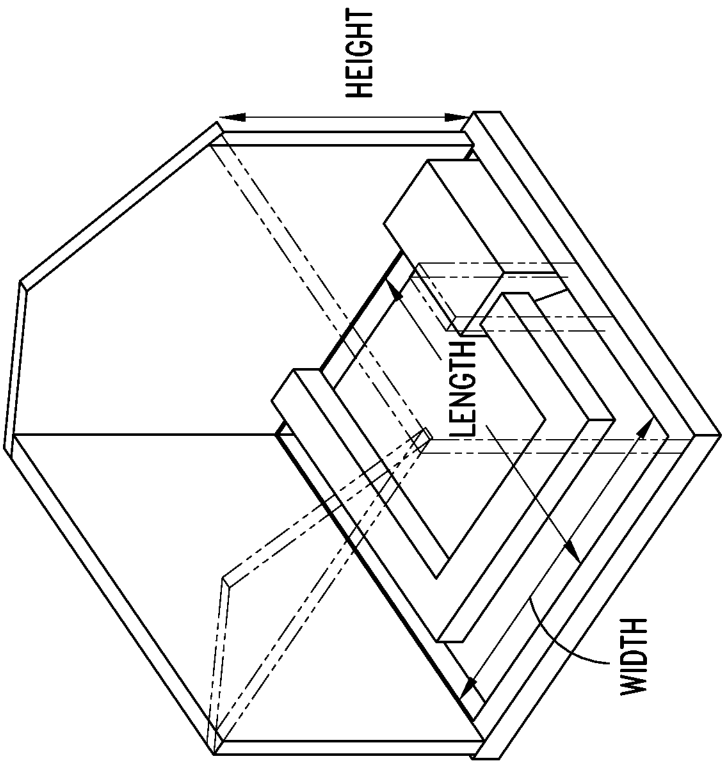

FIG. 1B

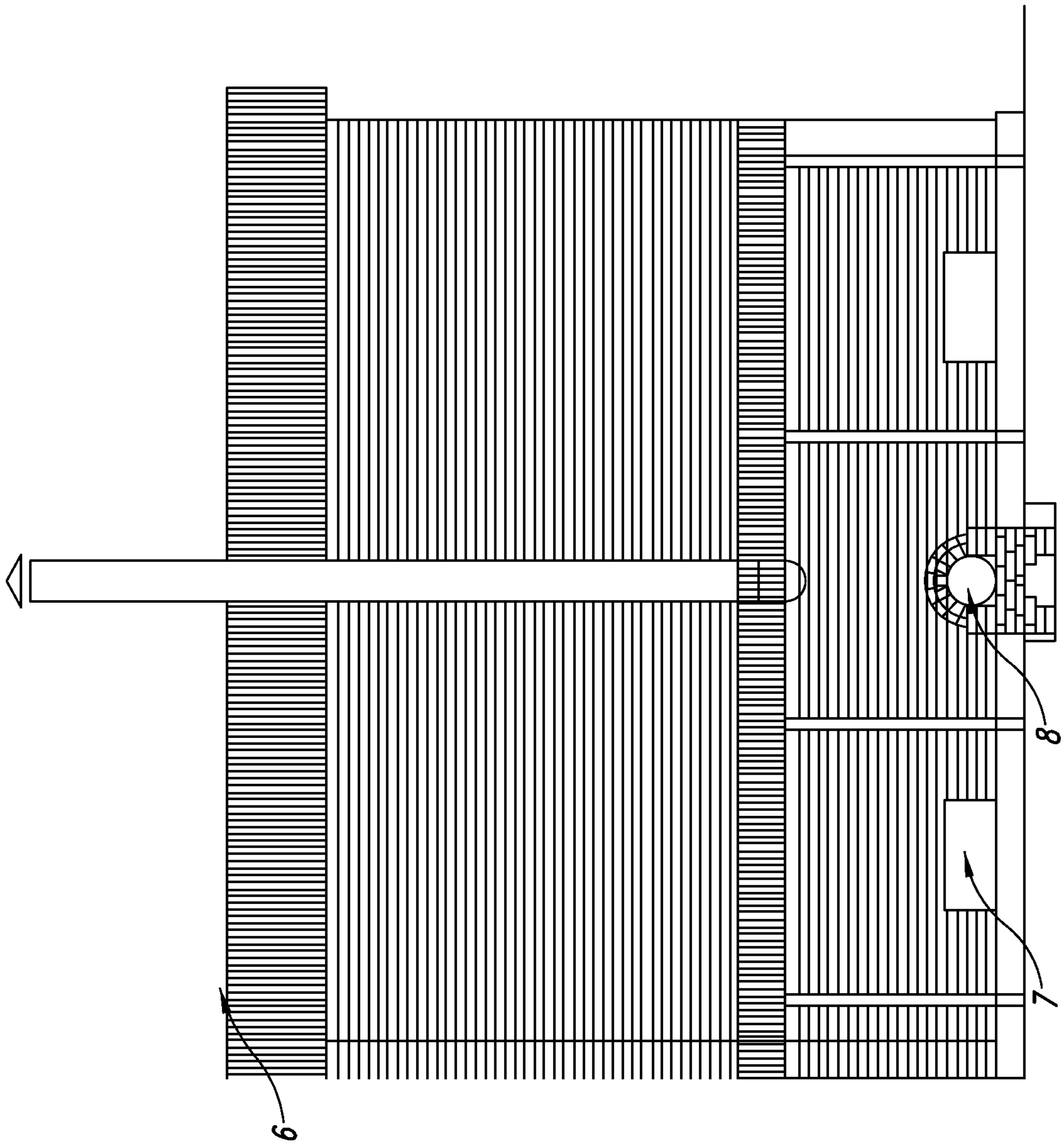

FIG. 2A

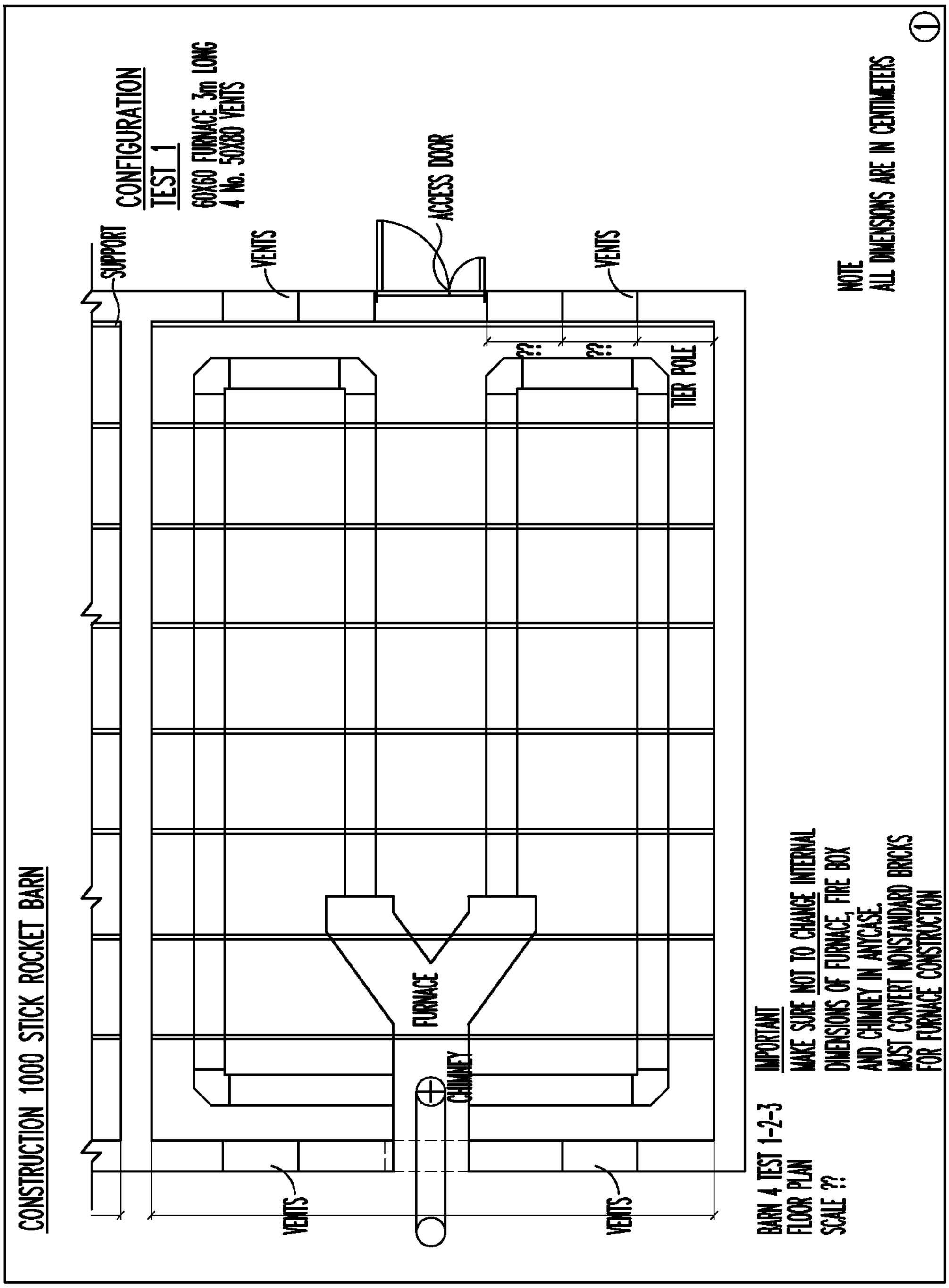
CONSTRUCTION 1000 STICK ROCKET BARN
CONFIGURATION
TEST 1
60X60 FURNACE 3m LONG
4 No. 50X80 VENTS
SUPPORT
VENTS
ACCESS DOOR
VENTS
??
??
TIER POLE
FURNACE
CHIMNEY
VENTS
VENTS
BARN 4 TEST 1-2-3
FLOOR PLAN
SCALE ??
IMPORTANT
MAKE SURE NOT TO CHANGE INTERNAL
DIMENSIONS OF FURNACE, FIRE BOX
AND CHIMNEY IN ANYCASE.
MUST CONVERT NONSTANDARD BRICKS
FOR FURNACE CONSTRUCTION
NOTE
ALL DIMENSIONS ARE IN CENTIMETERS
1

FIG. 2B

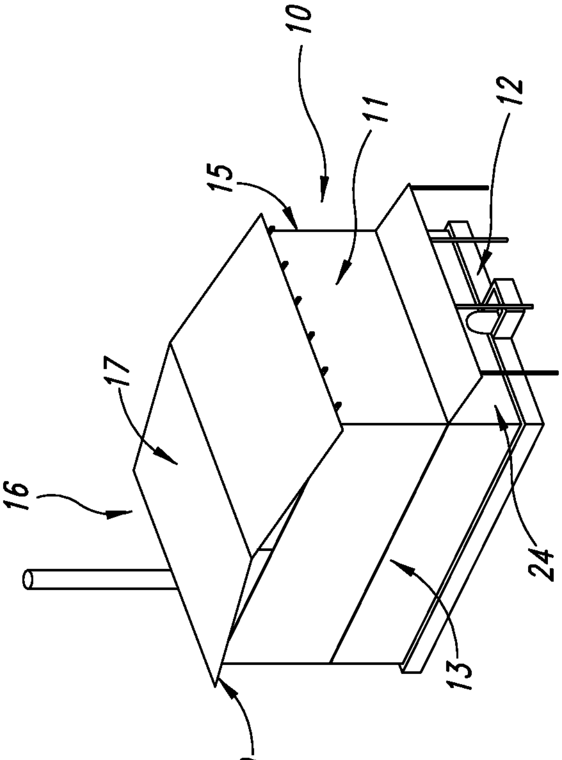

FIG. 3A

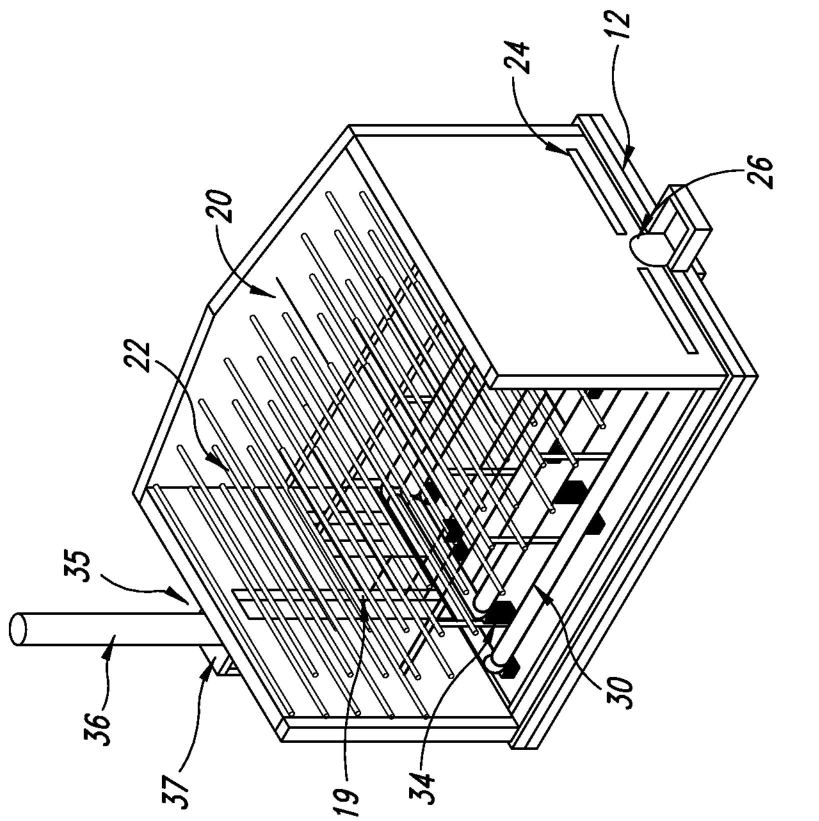

FIG. 3B

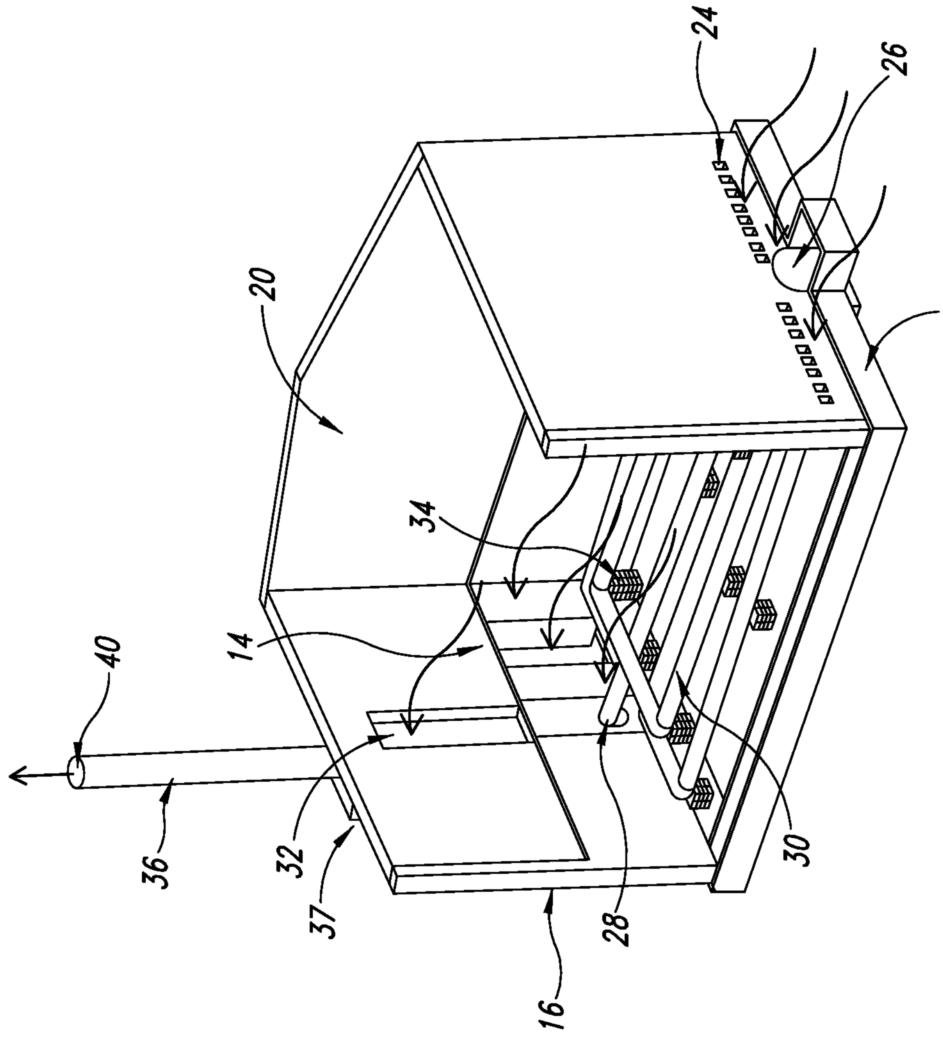

FIG. 3C

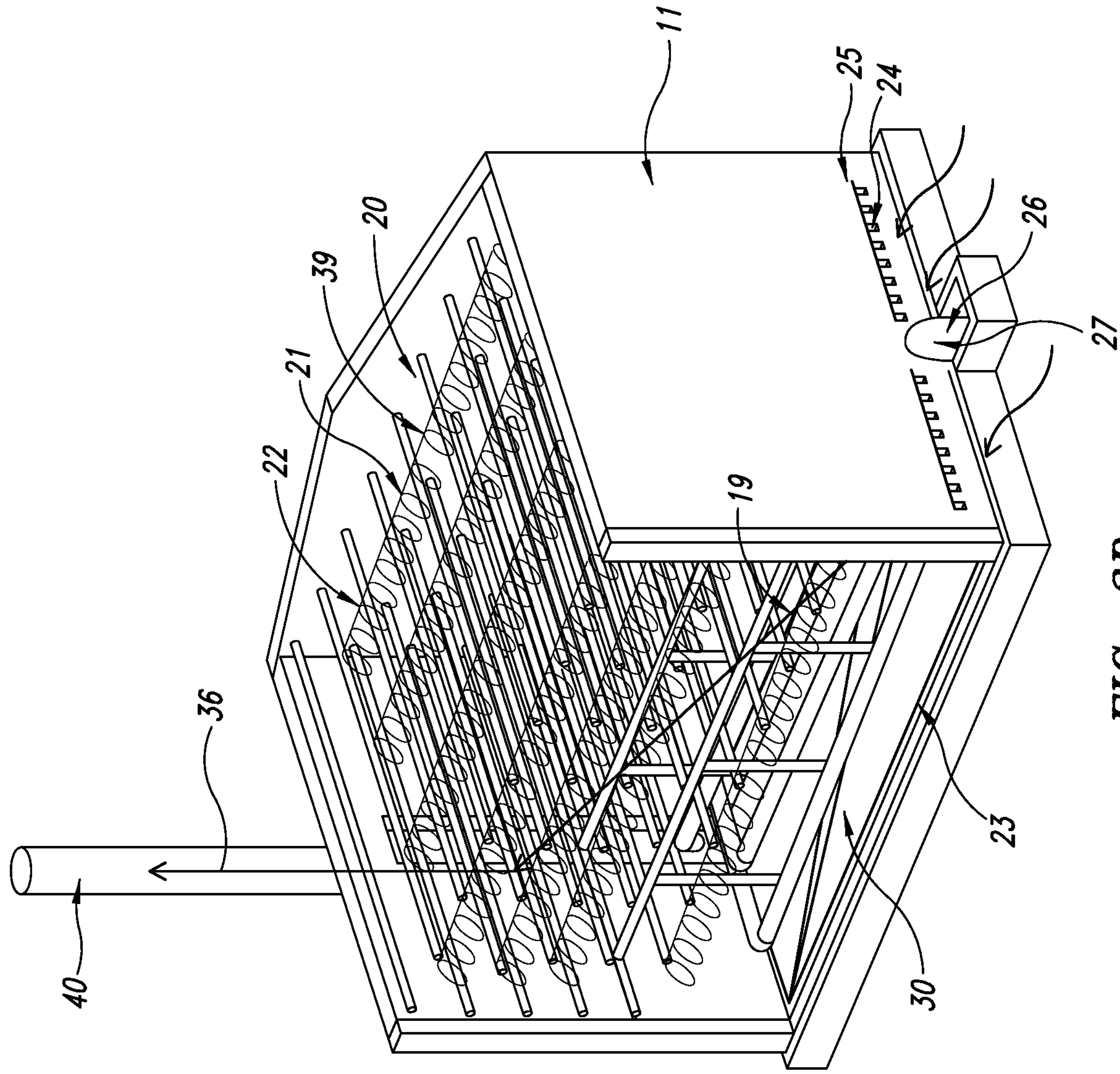

FIG. 3D

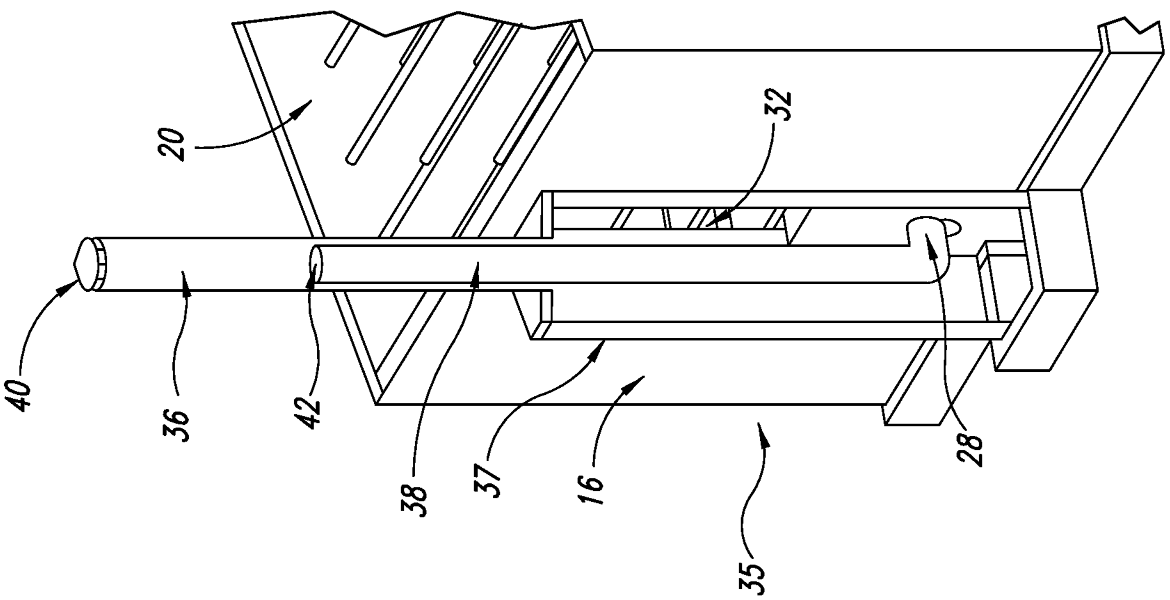

FIG. 3F

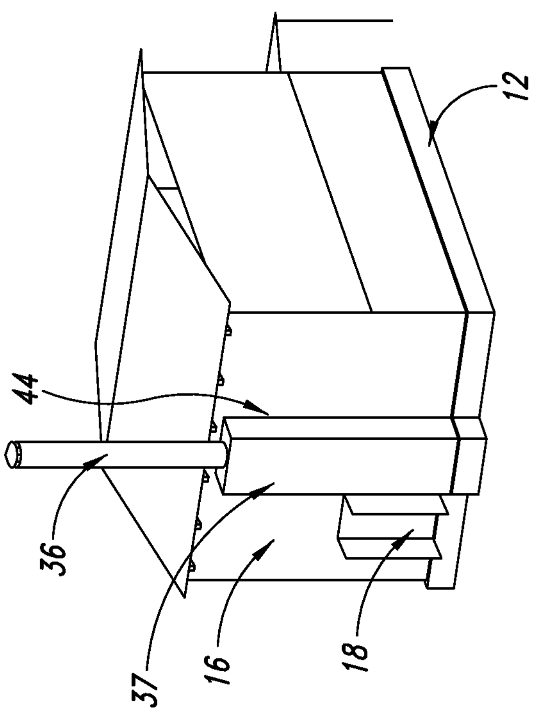

FIG. 3E

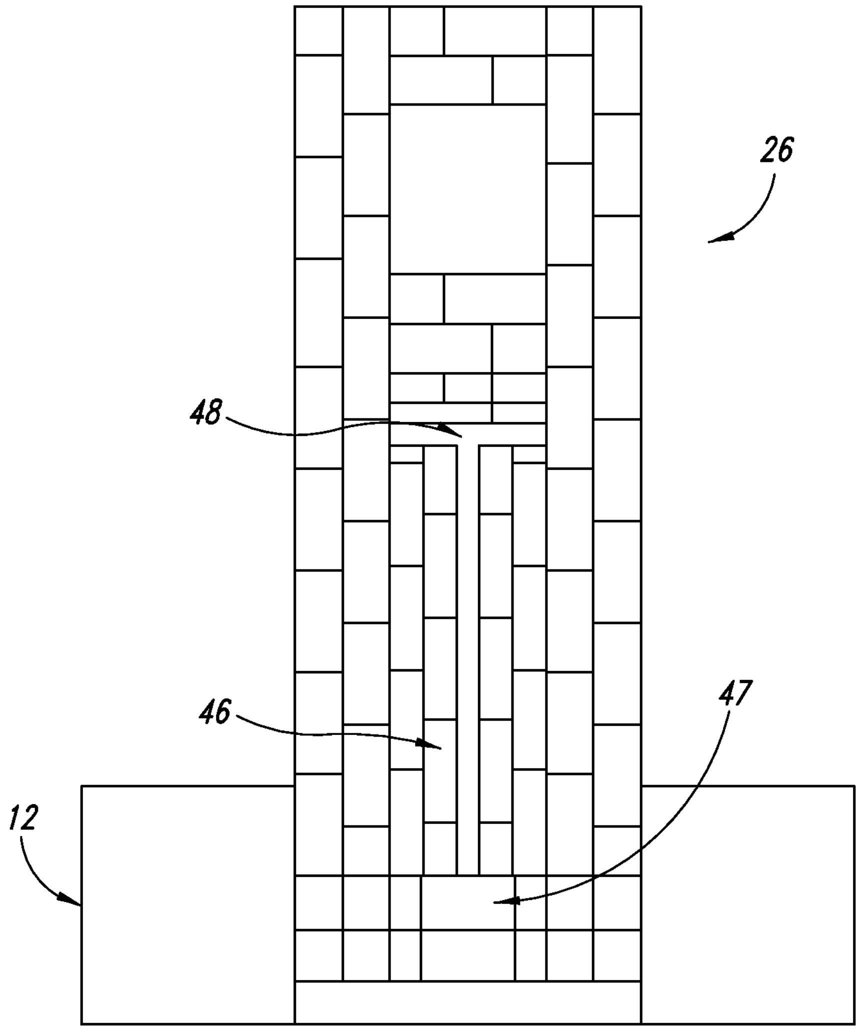

FIG. 3G

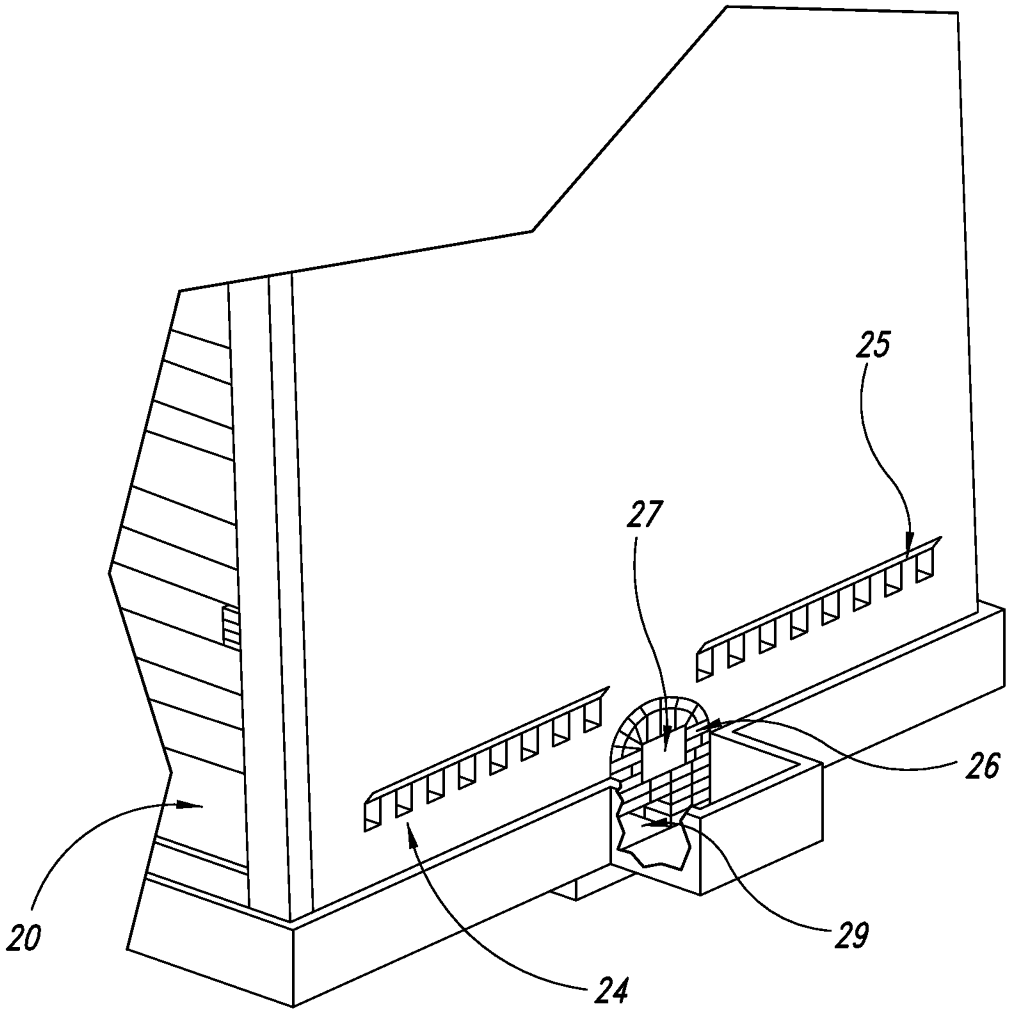

FIG. 3H

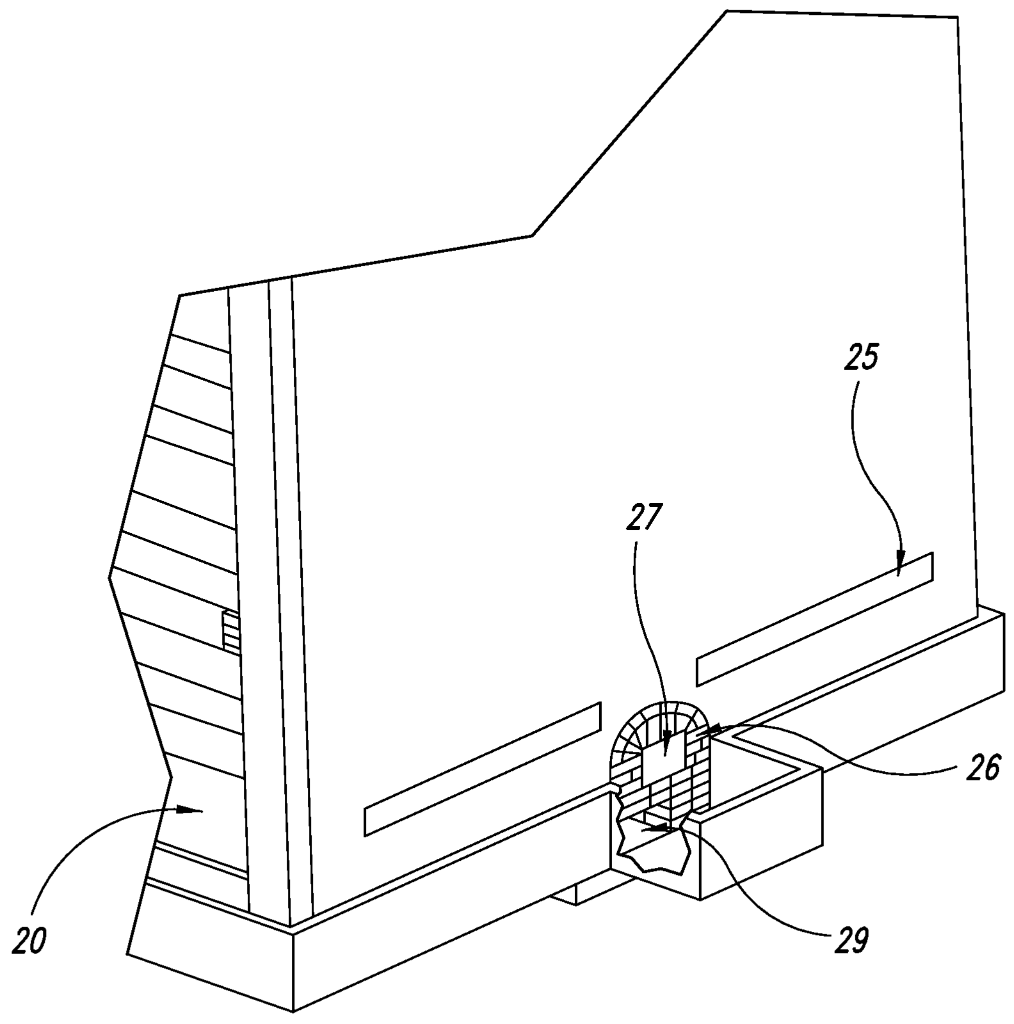

FIG. 3I

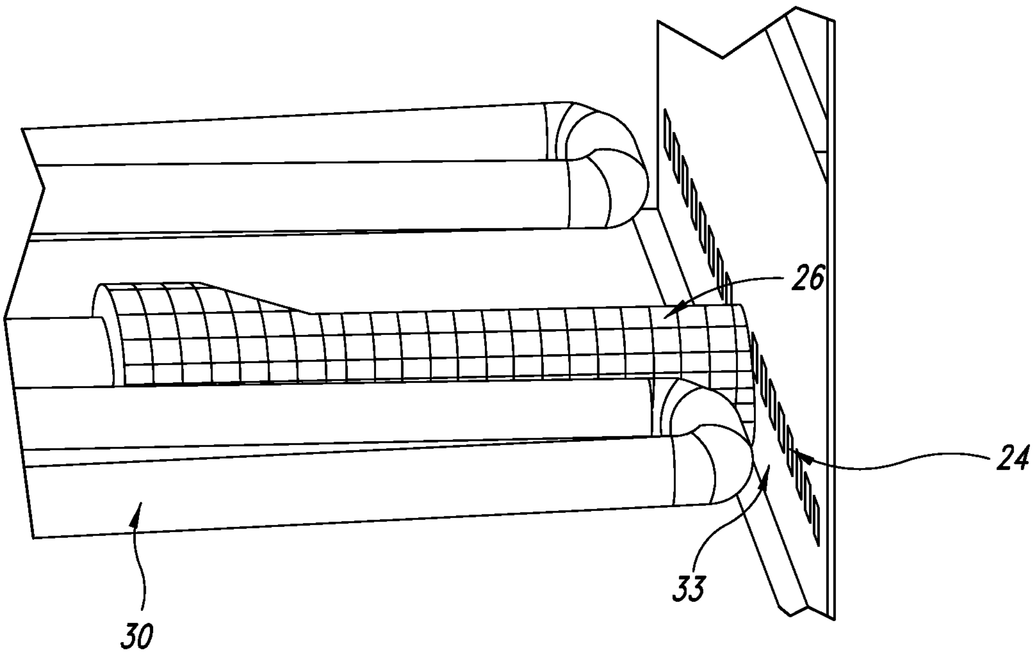

FIG. 3J

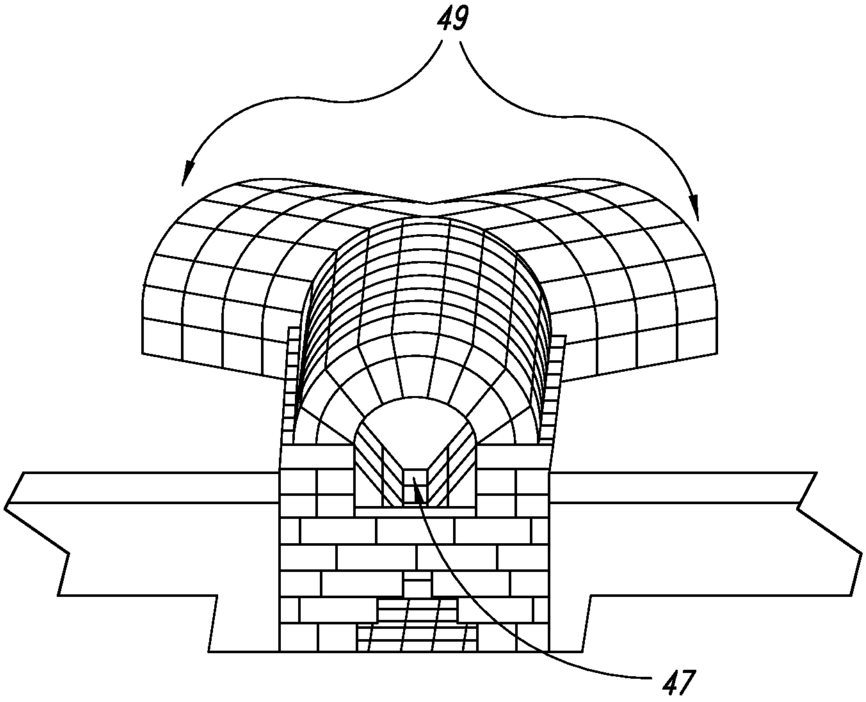

FIG. 3K

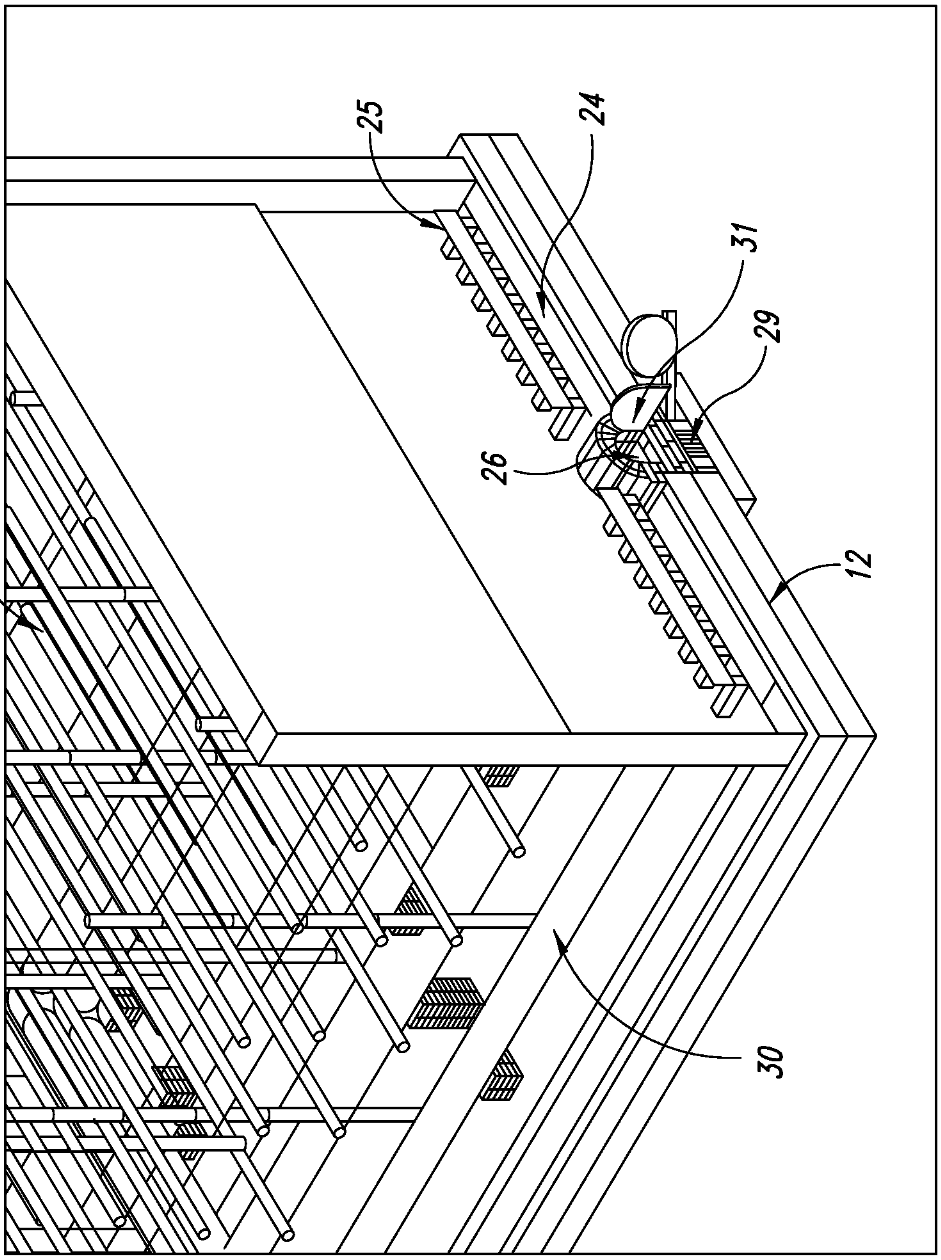

FIG. 4A

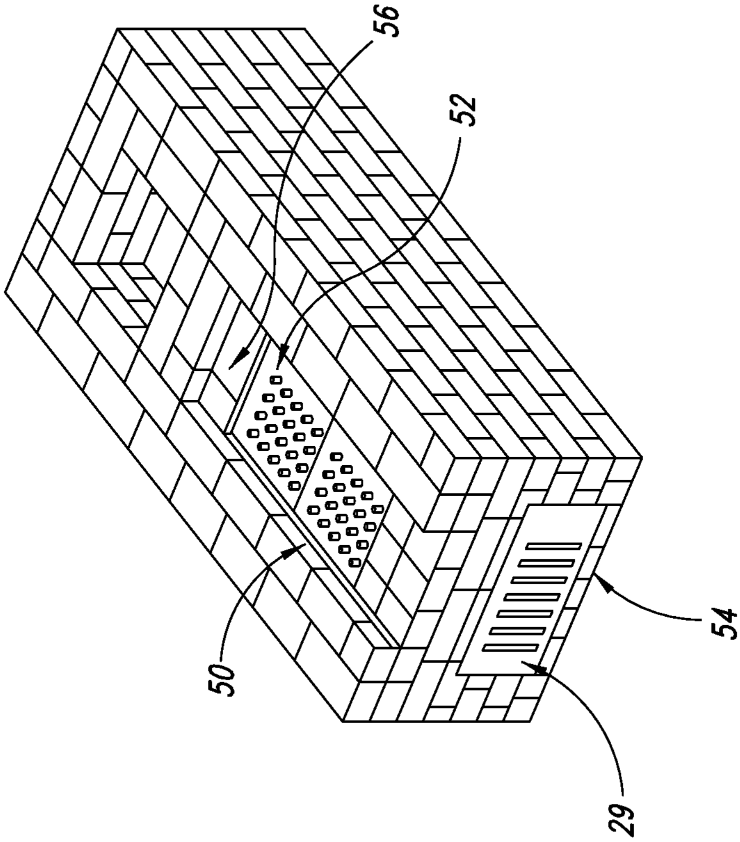

FIG. 4B

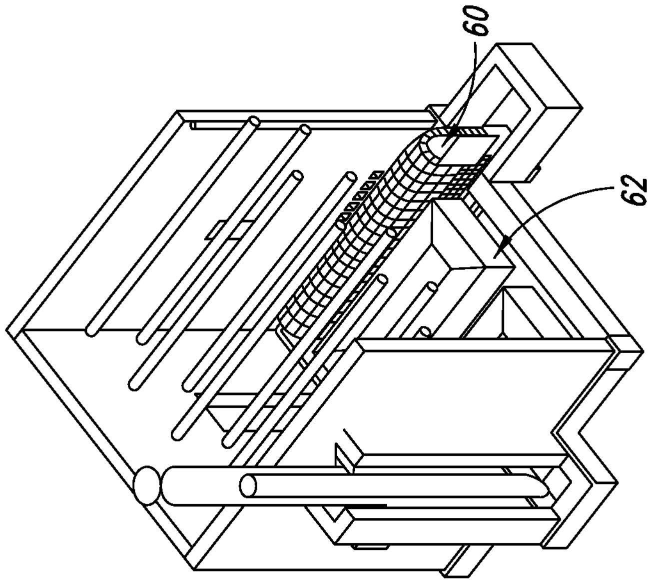

FIG. 5B

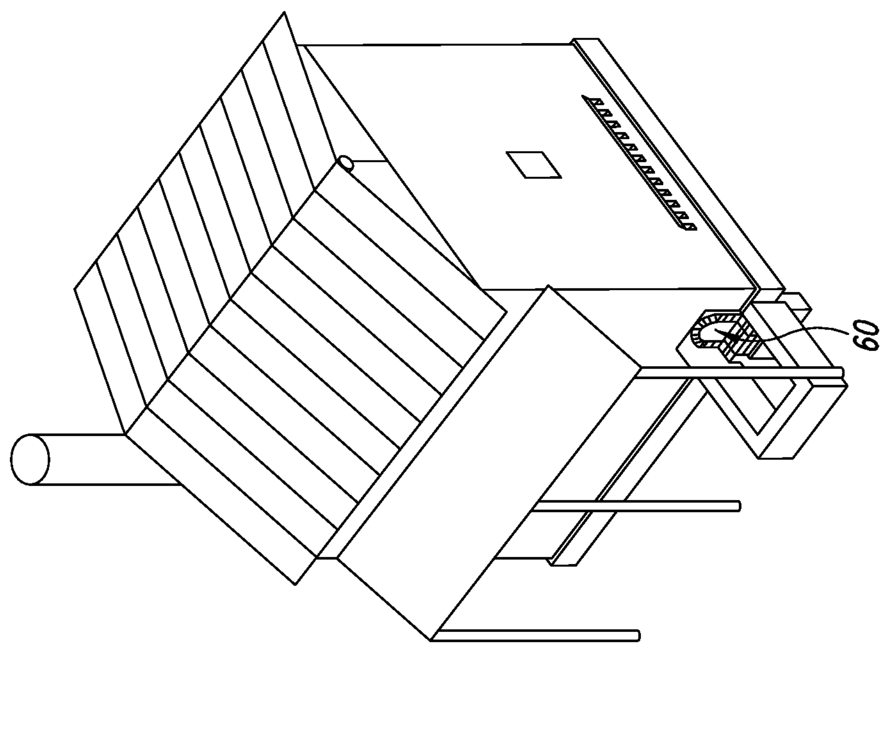

FIG. 5A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/053395

A. CLASSIFICATION OF SUBJECT MATTER

F26B 9/02(2006.01)i, A24B 1/02(2006.01)i, A24B 3/04(2006.01)i, F26B 3/02(2006.01)i

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)
F26B 9/02; F23B 80/00; F24H 3/06; F24D 3/10; F24D 15/00; F24D 3/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:"cure, combustion, gas, convective, vent, chimney"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-2010-0011810 A (KIM, NO SIK) 03 February 2010 See figures 1, 4	1-20
A	KR 10-2009-0030013 A (AN, JIN GEUN) 24 March 2009 See figures 1-6	1-20
A	JP 2009-068817 A (MIYATANI KAZUO et al.) 02 April 2009 See figure 1	1-20
A	JP 55-038474 A (-) 17 March 1980 See figures 1-2	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 SEPTEMBER 2011 (27.09.2011)	**28 SEPTEMBER 2011 (28.09.2011)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 189 Cheongsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea	KO, Jong Woo
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5496

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2010/053395

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 10-2010-0011810 A	03.02.2010	None	
KR 10-2009-0030013 A	24.03.2009	None	
JP 2009-068817 A	02.04.2009	None	
JP 55-038474 A	17.03.1980	None	