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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 May 2017 (11.05.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/079728 A1

(51) International Patent Classification:
F24B 1/02 (2006.01) *F24B 1/26* (2006.01)
F24B 1/191 (2006.01) *F24B 1/28* (2006.01)

(21) International Application Number: PCT/US2016/060794

(22) International Filing Date: 7 November 2016 (07.11.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/252,213 6 November 2015 (06.11.2015) US

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(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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

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(54) Title: BIOMASS STOVE WITH COMBUSTION CHAMBER, VENT DOOR, AND ASH DRAWER

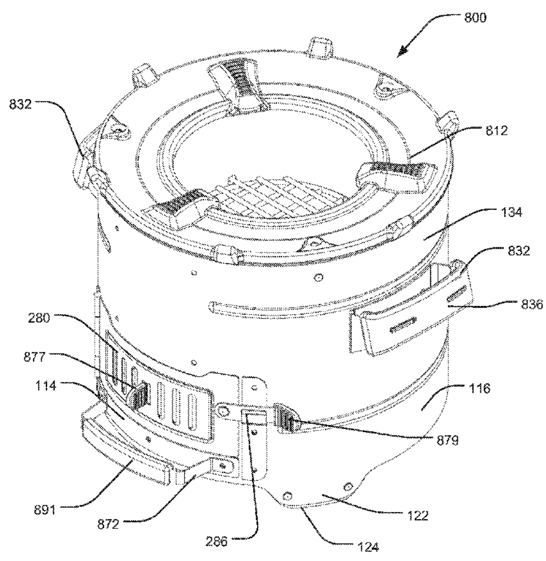

Fig. 8

(57) Abstract: Disclosed herein is a biomass stove comprising an inner combustion chamber for reducing loss of radiant heat from the fuel bed. The disclosed stove may further include a combination vent door and ash drawer designed to enhance boil time and simmer control.

WO 2017/079728 A1

Published:

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

TITLE

BIOMASS STOVE WITH COMBUSTION CHAMBER, VENT DOOR, AND ASH DRAWER

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. provisional application No. 62/252,213 titled "Biomass Stove with Combustion Chamber, Vent Door, and Ash Drawer," filed on November 6, 2015, the disclosure of which is hereby incorporated herein by reference in its entirety.

FIELD

Disclosed herein are stoves and cooking apparatus for use in confined areas, and having one or more features for enhancing cooking efficiency.

BACKGROUND OF THE INVENTION

About half of the world's population cooks over a biomass fire. Use of biomass as an energy source has led to deforestation as well as a decrease in indoor air quality. In Africa, this biomass fuel source is typically charcoal.

Charcoal stoves may burn relatively smoke free (i.e. low production of particulate matter), however they tend to produce high levels of carbon monoxide (CO). This may be caused by inefficient or incomplete combustion of charcoal fuel. While production of CO may not pose a significant problem when cooking in open spaces, such as out of doors, when charcoal combustion takes place within a living space or other enclosed space, CO may build-up causing sickness or death.

CO is a colorless, odorless, tasteless toxic gas produced by incomplete combustion in fuel-burning. CO poisoning may result in headaches, nausea, dizziness, or confusion. Left undetected, CO exposure can be fatal, and in the United States alone, accidental CO poisoning results in about 15,000 ER visits a year.

Because CO is a byproduct of incomplete combustion, procedures that enhance combustion will reduce the production of CO. Those of skill in the art will understand that enhancing combustion may generally be accomplished in at least three ways – by increasing the duration of combustion, raising the temperature at which combustion takes place, or optimizing the mixing of oxygen and fuel.

In some cases, maximizing one factor may lead to minimization of a second factor. For example, optimizing the mixing of oxygen often requires maximizing airflow, but this may also lead to a decrease in combustion temperature as cooler ambient air enters the combustion area. Thus, enhancement of combustion often requires a balancing of these factors.

It is easier to control the factors that enhance combustion when the fuel source is gaseous rather than solid. Developed countries have largely replaced solid fuel with gaseous fuels for cooking and heating. But, as is evident from the CO poisoning statistics presented above, the use of gaseous fuels alone will not prevent CO poisoning when fuels are burned indoors.

Modern appliances are often controlled by sophisticated electronics, and combustion products are normally vented directly out of the living space to help reduce CO production and/or buildup. In contrast, in developing countries where charcoal combustion may take place on simple cook stoves, within the living space, and with little or no dedicated ventilation, stoves should be engineered to balance efficiency and CO production.

Reducing CO emissions may require both a reduction in the production of CO as well as combustion of any CO that is produced.

Fuel burn rate, airflow rate, and operating temperature are some of the most important and basic characteristics of a stove. Charcoal stoves generally operate at higher temperatures than other biomass stoves. The top of a charcoal fuel bed may be about 1000 °K [~730 °C]. CO oxidation is affected by combustion temperature, residency time, and oxygen concentration.

In many rural and developing communities, especially in Africa and Asia, charcoal is a major energy source. Charcoal is made by partially cooking biomass, such as wood, in a low oxygen environment. This process, often referred to as pyrolysis, reduces the water and volatile content of the biomass rendering it mostly carbon. Charcoal burns at very high temperatures. In some cases, charcoal may burn at or about 1100 °C.

Even before charcoal is used as an energy source, production of charcoal contributes to deforestation and increases greenhouse gases (both from direct production of charcoal and as an indirect result of loss of trees). Thus an increase in the efficiency of charcoal stoves may decrease the need for charcoal with an accompanying decrease in deforestation and greenhouse gases.

Existing charcoal stove designs, for the most part, rely on traditional materials such as brick, stone, or ceramics, while some stoves may also be constructed of metal. Mass produced ceramic stoves may have increased efficiency over traditional charcoal stove designs, but ceramic stoves tend to have high production and distribution costs due to the time needed to construct them (e.g. casting, drying, and firing) and their weight. Metal stoves may be lighter weight and rapidly constructed, but metal stoves are usually less-efficient than ceramic stoves due to quenching of the combustion temperature. In addition, some metal combustion chambers may be more susceptible to corrosion.

Many manufactured stoves, designed for use with solid biomass fuels, are not specifically designed to lessen production of dangerous combustion products. Those manufactured stoves that do address indoor pollution are generally not ideal, either because they rely on drastic changes in traditional behavior (such as limiting use of solid fuels, moving the stoves out of doors, or depending on expensive or impractical venting), or they are financially out of reach for the poor. A cooking/heating alternative that is compatible with traditional behavior, inexpensive, and capable of lessening production of dangerous gases, may help prevent death and disease especially among persons of limited income.

What is needed is a charcoal stove that reduces CO production while being efficient, inexpensive, and/or corrosion-resistant, as well as financially accessible to persons in developing nations. A metal stove with these qualities may be inexpensively manufactured and distributed in rural and developing countries.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 is an isometric view of a biomass stove.

Fig. 2 is an isometric exploded view of the stove of Fig.1.

Fig. 3A is a cross-sectional view of the stove of Fig. 1 taken along line 3A-3A.

Fig. 3B is an isometric view of the components shown in Fig. 3A.

Fig. 4A is an isometric view of the air intake chamber and combustion chamber of the stove of Fig. 1.

Fig. 4B is an isometric view of the components shown in Fig. 4A.

Fig. 5 is an isometric view of the drawer of the stove of Fig. 1

Fig. 6 is an isometric view of the drawer and door assembly of the stove of Fig. 1.

Fig. 7 is an isometric view of the cooktop of the stove of Fig. 1.

Fig. 8 is an isometric view of an alternate embodiment of a biomass stove.

Fig. 9 is an isometric view of the cooktop of the stove of Fig. 8.

BRIEF DESCRIPTION

The present disclosure describes a metal biomass stove that may lower production costs and therefore a potential sale price while increasing durability and customer satisfaction by reducing fuel consumption and CO emissions. The stove combustion chamber may be designed to increase the efficiency of the stove when burning a solid fuel energy source by minimizing the amount of radiant heat losses. The minimization of heat losses may be achieved by the optimized design of a combustion cone located in an upper internal section, as well as the optimized height of the overall stove. The optimized design of a fuel bed may lead to increasing the radiation directed towards the cooking apparatus used in conjunction with the stove while maintaining an ideal air/fuel ratio. Lower production costs may be achieved through the design of features related to the drip pan, as well as the design of the support feet located on the bottom of the stove. In addition to the reduced fuel consumption requirement and emissions, increased customer satisfaction may be achieved with an insulated air intake chamber that prevents damaging a supporting surface.

DETAILED DESCRIPTION

General Stove

An example of a stove 100 comprises five sections: an upper internal section 102 with an upper combustion chamber 104 and a lower combustion chamber 106, a lower internal section 102 with an air intake chamber 110, a cooktop 112, an ash drawer 114, and an outer body 116.

The stoves 100 and apparatuses disclosed herein may be generally constructed of metal to decrease the overall weight as well as the cost of manufacture and transport. The use of metal may also aid in reducing the thermal mass of the stove. In some embodiments, the disclosed stoves may include one or more non-metal materials. In some embodiments, the stove may include stone or ceramics as well as insulating materials. Stoves with greater thermal mass may absorb more energy generated by combustion. This absorbed energy raises the temperature of the stove body. The energy absorbed by high thermal mass stoves may be wasted as it might otherwise be used for cooking. Additionally, energy lost to a high thermal mass body might also have been used to enhance combustion. Thus, by reducing the thermal mass of a stove, the stove may be more efficient in both heating a cooking vessel and preventing incomplete combustion.

The air intake chamber 110 may be designed to allow access to the lower internal section 108 such that a consumer may place paper within the lower combustion chamber 106 to ignite, which may in turn ignite the fuel positioned upon a grate 118. Access to the lower combustion chamber 106 may also aid in removing ash debris, and providing an additional source to create air turbulence when starting the stove 100.

In addition to an optimized lower combustion chamber angle, an overall internal height, which includes height of the air intake chamber 110, lower combustion chamber 106, and upper combustion chamber 104 may be optimized. When the stove 100 is in use, the upper combustion chamber 104 may act as a chimney so as to force more air through the system and increase the temperature of the stove 100, thereby reducing the time to boil of liquid in a cooking vessel on the cooktop 112. If the upper combustion chamber 104 is too short and the fuel bed, which sits on the grate 118 located at the intersection of the lower combustion chamber 106 and upper combustion chamber 104, is too high, not enough of the upper combustion chamber 104 gets heated and the positive chimney effects may be lessened. However, it may be desirable from a consumer standpoint to have the overall height of the stove 100, which is contingent on the overall internal height, be minimized so that the stove 100 can be easily used by many consumers. Therefore, some examples of the design embody an internal height that will incorporate the chimney effect while still meeting consumer needs for a small overall height.

Fig.1 shows an isometric view of one embodiment of an improved design for biomass cook stove 100 as disclosed herein. Fig. 2 shows an exploded view of the stove 100, in which the cooktop 112, outer body 116, and additional internal components are visible. These internal components may comprise the upper internal section 102 and the lower internal section 108, also visible in this exploded view. Fig. 3A is a cross section view of the stove along line 3A-3A in Fig. 1. Fig. 3B is an isometric view of the components shown in Fig. 3A.

Outer Body

As shown in Figs. 1-3B, the outer body 116 of the stove may be generally cylindrical and may further comprise a bottom 120 at or near the lower portion of the cylinder. The bottom 120 may be designed to contact a surface to position the stove 100 upon. In some embodiments, a plurality of legs 122 may be formed at or near the edge of the bottom 120, proximal the cylindrical portion of the stove's outer body. The legs 122 may help to raise the bottom 120 of the stove above the surface, such as a floor, table, or other suitable surface. The legs 122 may further help protect the surface from damage due to heat from the stove 100. In some embodiments, each leg 122 may comprise a foot 124 for contacting the surface. In some embodiments, the foot 124 may be formed by compressing rubber 126 between two metal surfaces: a foot outer body 128 and an internal foot guide 130. This innovative foot structure allows for protection of the surface that the stove 100 sits upon, minimizes the amount of rubber 126 needed for the foot 124, provides an anti-slip contact, and provides a non-marring material for contacting the surface. In many embodiments, the foot 124 may also allow for a decreased production cost of the stove 100 because a decreased amount of rubber 126 can be used while still maintaining a stiff leg 124 to support the stove 100. The outer body 116 may also include a plurality of handles 132 for transporting the stove 100. The handles 132 may be connected to the exterior surface 134 of the outer body 116 as shown in the embodiment of Fig. 1. In some embodiments, such as that shown in Fig. 1, each handle 132 may further include a grip structure 136 positioned about or surrounding the handle 132, the grip 136 providing a larger structure for grasping and one or more indentations that may aid in gripping and dissipating heat. In other embodiments, the handles 132 may be integral structures formed with the outer body 116.

A stove inlet 140 may be formed in the outer body 116. In some examples, the stove inlet 140 may be an aperture formed in the exterior surface 134 extending through to the inner surface 138. In some examples, the stove inlet 140 may be rectangular shaped or similar to the shape of the inlet 200 of the air intake chamber 110, shown in Figs. 3A-4B.

The inner surface 138 and bottom 120 of the outer body 116, when assembled with the cooktop 112, may form an outer cavity 142.

Fig. 8 is an isometric view of an alternate embodiment of a biomass stove. The biomass stove 800 of Fig. 8 is similar to the biomass stove of Figs. 1-7, but the stove 800 has a cooktop 812 and handles 832 that may be surrounded by a grip structure 836 and a handle 872 that extends from the ash drawer. The handles 832, handle 872, and grip structure 836 of Fig. 8 may be different than the those of stove 100 in Fig. 2 in that the handles 832 and handle 872 may be made from sheet metal and generally flat, as opposed to the round bar shape of handles 132 in Fig. 2. In addition, the handles grip structure 836 may be generally flatter without one or more indentations compared to the handle grip structure 136 of Fig. 2. .

Cooktop

In addition to being shown in Figs. 1-3B, Fig. 7 shows an isometric view of the cooktop of the stove of Fig.1. The cooktop 112 may define an annular ring with an outer edge 156 that extends inward. The cooktop 112 may have an upper surface 150 and a lower surface 152 opposite the upper surface 150. The inner edge of the cooktop 112 may help define the combustion chamber outlet 154, which is generally centered within the cooktop 112. The combustion chamber outlet 154 may be formed as an aperture inside the outer edge 156 and extending between the lower surface 152 and the upper surface 150. In some embodiments, the cooktop 112 may be referred to as a drip pan.

Positioned about the cooktop 112 and extending upward and away from the upper surface 150 of the cooktop 112 may be a plurality of inner pot supports 158 and outer pot supports 160. In some examples, the pot supports 158, 160 may be positioned about the combustion chamber outlet 154 in a circular pattern. In some examples, the inner pot supports 158 may be positioned about a diameter formed by an inner drip pan lip 170 that is smaller than a diameter formed by an outer drip pan lip 172 that the outer pot supports 160 are positioned about.

In some examples, each pot support 158, 160 may have a raised upper surface 162 that is elevated above the upper surface 150 of the cooktop 112. The raised upper surface 162 may be connected to the upper surface 150 by a plurality of sidewalls 164. In some examples, four sidewalls 164 support the raised upper surface 162. In some examples, ribs 166 may be formed in the raised upper surface 162 of pot supports 158, 160. The ribs 166 may feature a concave shape directed towards the lower surface 152 of the cooktop 112. In some examples, the ribs 166 may have a length that is slightly curved to center about the combustion chamber outlet 154. In some examples, the inner pot support 158 has at least two ribs 166 and the outer pot support 160 has at least three ribs 166.

The pot supports 158, 160 may be designed to help position a pot or cooking vessel above the cooktop 112. The pot supports 158, 160 may further be designed to aid in providing a space between the cooktop 112 and the pot.

The drip pan 112 may extend from an outer edge 156 inward to the combustion chamber outlet 154. The upper surface 150 of the drip pan 112 may slope generally downward from the outer edge 156 of the cooktop 112 to an inner edge at or near the combustion chamber outlet 154. The upper surface may have a circular outer drip pan lip 172, and a circular inner drip pan lip 170, and a circular reservoir or valley 168 positioned between the drip pan lips 170, 172. The upper surface 150 of the drip pan 112 may be elevated (rise upward proximate the combustion chamber outlet 154) such that the reservoir 168 is at a lower elevation than either the circular outer drip pan lip 170 or the circular inner drip pan lip 170. The inner drip pan lip 170 and the outer drip pan lip 172 may be elevated, such that the depression or valley 168 is formed between the outer drip pan lip 172 and the inner drip pan lip 172. The valley created by the drip pan and the drip pan lip may define the drip pan reservoir 168. In various embodiments, the drip pan reservoir 168 may have a flat bottom or a v-shaped bottom. In various other embodiments the reservoir 168 may have a rounded bottom.

The drip pan 112 may also define a lower surface 152, which may include a plurality of drip pan tabs 174 that extend downward and away from the lower surface 152 of the drip pan 112, as shown in Fig. 7. In some examples, the drip pan tabs 174 are may have slots 176 that may be formed to receive a pin or rivet within the slot 176. In some embodiments, the cooktop 112 may at least partially rest upon the outer body 116 of the stove 100 by engaging a pin or rivet affixed to the inner surface 138 of the outer body 116. Slotting 176 of the tabs 174 may eliminate the need for a stove assembler to drill holes in the drip pan 112 in order to secure it to the stove 100. This feature may decrease the overall production cost of the stove 100 as it eliminates an extra step in the manufacture and assembly process.

When in use, combustion gases exiting the combustion chamber outlet 154 may heat a pot by convective heat transfer as combustion gasses flow underneath and around the pot or cooking vessel positioned above the combustion chamber outlet 154 atop the pot supports 158, 160 of the cooktop 112. The cooktop / drip pan 112 reservoir 168 may aid in protecting the upper combustion chamber 104, lower combustion chamber 106 and fuel bed, for example from corrosion or quenching if the pot were to boil over when placed on the cooktop 112, such that overflow liquid is deposited in the valley 168. The position of the reservoir 168 proximate the combustion chamber outlet 154 may help to promote evaporation of liquid from the reservoir 168 before the liquid spills into the combustion chamber 104, 106.

Fig. 9 is an isometric view of the cooktop of the stove of Fig. 8. The cooktop 812 may be similar to the cooktop 112 of Fig. 7. Differences may be in that there are a plurality of internal pot supports 858, centered about the combustion chamber outlet 154, each with a plurality of ribs 866 formed in a raised upper surface 862. In addition, the outer pot supports 860 may be positioned on the outer edge 856 and extend upward and away from the center of the stove 800. Stove 800 may also have connector ports 875 formed within the cooktop. In some examples, the connector ports 875 may be through holes formed through the upper surface 850 and lower surface 152 of the cooktop 800. In some examples, the connector ports 875 may be utilized with a fastened to secure the cooktop to the stove assembly 800.

Upper and Lower Combustion Chambers

The stove 100 may further comprise an internal portion comprising an upper internal section 102 and a lower internal section 108 positioned within the outer body 116 of the stove 100. Fig.3A shows the upper internal section 102, which may comprise an upper combustion chamber 104 and a lower combustion chamber 106. The upper combustion chamber 104 may extend downward from the inner edge of the cooktop 112 toward the lower combustion chamber 106. The upper combustion chamber 104 may be fluidly connected to the combustion chamber outlet 154 that is visible in Fig. 2. The lower internal section 108 may comprise an air intake chamber 110, the inlet 200 to the air intake chamber 110 is visible in Fig. 4A. Other aspects of the combustion chamber will be described in more detail below.

As shown in Figs. 4A and 4B, in some embodiments the upper combustion chamber 104 is cylindrically shaped with a substantially constant radius. In various other embodiments, the upper combustion chamber may define a shape other than a cylinder. In some embodiments, the lower combustion chamber 106 may define a conical shape. In various other embodiments, the lower combustion chamber 106 may define a shape other than a cone. For example and without limitation, the lower combustion chamber 106 may define an oval, a square, a rectangle, or other regular or irregular shape, while generally maintaining a larger area at an upper junction 202 than a lower junction 204.

The lower combustion chamber 106 is joined to the upper combustion chamber 104 at the upper junction 202 and joined to the air intake chamber 110 at the lower junction 204. As shown in the embodiments of Fig. 3A-4B, the lower combustion chamber 106 may define a larger, upper diameter 208 at or near the upper junction 202 with the upper combustion chamber 104, and a smaller, lower diameter 206 at or the near the lower junction 204 with the air intake chamber 110. In some examples, the inlet 214 of the lower combustion chamber 106 is defined by the smaller, lower diameter 206.

As shown in Fig. 4B, the angle 212 of the lower combustion chamber 106 is dependent on a height 210 of the lower combustion chamber 106 and the upper diameter 208 and lower diameter 206 of the lower combustion chamber. When the stove 100 is in use, radiant heat may leak through the inlet 200 of the air intake chamber 110. One method to minimize this leakage is to decrease the amount of the fuel bed that can be observed through the inlet 200 of the air intake chamber 110, such that the radiation originating in the upper combustion chamber 104 and being directed out of the inlet 200 of the air intake chamber 110 is minimized.

When the stove 100 is in use, heat directed towards the inlet 214 of the lower combustion chamber 106 decreases the overall heat that can be directed at the cooktop 212. One method to minimize the heat directed towards the inlet 214 of the lower combustion chamber 106 is to decrease the lower diameter 206 forming the inlet 214 of the lower combustion chamber 106, thereby reflecting heat back towards the fuel source and the cooktop 212, in part due to the conical shape of the lower combustion chamber 106. The slope angle 212 of the lower combustion chamber 106 of a present embodiment is optimized to minimize the radiation leakage through the inlet 200 of the air intake chamber 110, maximize the reflected heat back towards the fuel that is placed on top of the grate 118, and maximize the size of the fuel bed that can be stored on top of the grate 118.

A grate 118 may be positioned at or near the upper junction 202, between the upper combustion chamber 104 and the lower combustion chamber 106. The grate may be made of a metallic material, and designed to accept a fuel bed of biofuel such that the fuel bed may rest upon the grate 118. In many embodiments, the grate may be attached to or inserted (see Fig. 8) through the wall of the upper or lower combustion chamber. This may aid in retaining the grate when the stove is turned upside down.

Air Intake Chamber

As seen in Figs. 3A-4B, the lower internal section 108 features the air intake chamber 110. The air intake chamber 110 is comprised of a top segment 218 and bottom segment 220, two side segments 222, 224, a rear segment 226, an inlet 200, and an outlet 216. When assembled, the outlet 216 of the air intake chamber 110 mates with the inlet 214 of the lower combustion chamber 106 and is similarly shaped to the inlet 214 of the lower combustion chamber 106. In some cases, the outlet 216 is a circular aperture formed the top segment 218.

In some examples, the top and bottom segments 218, 220 are substantially parallel to each other and a plane formed by the bottom 120 of the stove's outer body 116. The rear segment 226 is substantially perpendicular to the top and bottom segments 218, 220 and is partially cylindrical to accommodate the mating of the outlet 216 of the air intake chamber 110 to the inlet 214 of the lower combustion chamber 106. The side segments 222, 224 have a substantially constant height to connect the top segment 218 and the bottom segment 220. The side segments 222, 224, the top segment 218, and the bottom segment 220 form the inlet 200 of the air intake chamber 110. In some examples, the inlet 200 can be considered an aperture formed by the side segments 222, 224, the top segment 218 and the bottom segment 220 of the air intake chamber 110. The inlet 200 may comprise a curved plane with a radius substantially equal to the radius of the outer chamber 116 when the outer chamber 116 is cylindrically shaped.

The air intake chamber 110 may be formed by using three separate pieces of material. The top segment 218 may be made with a substantially flat region 228 and two flanges 230, 232 that extend downward to mate with a surface of the side segments 222, 224. The side segments 222, 224 and rear segment 226 may be formed from one piece of material that also includes flanges 234, 236 that extend horizontally from the side segments 222, 224 to allow mating to the bottom 120 of the outer body 116. In most embodiments, the rear 226 and side segments 222, 224 may be manufactured from a unitary piece of metal, or two or more pieces that have been connected or fused. The bottom segment 220 may comprise a flat region 238 and a plurality of flanges 240, 242 that extend downward that allow for the flat region 238 of the bottom segment 220 to be elevated from the bottom 120 of the outer body 116. A bottom cavity 244 is formed by the bottom flanges 240, 242, the lower portions of the side segments 222, 224 of the air intake chamber 110, the bottom segment 220 of the air intake chamber 110 and the bottom 120 of the outer body 116 wherein insulation may be placed to help protect the bottom 120 of the outer body 116 and the supporting surface underneath from excess heat.

The bottom segment 220 of the air intake chamber 110 may define a subfloor 246. The subfloor 246 may be positioned at a distance above the bottom 120 of the outer body 116 that is equal to or larger than the thickness of insulation that may be installed in the cavity 244.

Fig. 3B shows an isometric view of the stove from Fig.3A. In this figure, flanges 240, 242 are visible that help to define the bottom cavity 244. The flanges 240, 242 may be extensions of the side segments 222, 224 of the air intake chamber 110 that extend below the bottom segment 220 of the air intake chamber 110.

Ash Drawer

Fig. 5 displays an embodiment of an ash drawer 114. The ash drawer 114 may slide through the stove inlet 140 and the inlet 200 of the air intake chamber 110. A portion of the ash drawer 114 may be adjustably stored within an interior portion of the air intake chamber 110. A bottom surface 260 of the ash drawer 114 may contact a top surface of the bottom segment 220 of the air intake chamber 110. In some examples, the ash drawer has two side sections 264, 266 which may contact an inside surface of the side segments 222, 224 of the air intake chamber 110. The ash drawer 114 may comprise a plurality of tabs 268 that are mounted to an inside surface 276 of a front section 274 of the ash drawer 114. The tab or tabs 268 may act as a lip and aid in securing the ash drawer 114 in place when a venting door (shown in Figs. 2 and 6) is in a closed position. The ash drawer 114 may further comprise a handle 272 on an outside surface 270 of the front section 274 of the ash drawer 114 to allow consumers to use the drawer 114 while being protected from the potentially hot temperature of the drawer 114. The drawer 114 may be used by consumers to hold ashes of spent fuel. The drawer 114 may also be removed and used as a fan to increase the amount of air supplied to the stove 100.

The stove 800 may also have grip feature 891 adjacent features of the ash drawer 114. In some examples, a grip 891 may surround or be attached to the handle 872. The grip 891 may protect a user from excess heat transferred to the ash drawer handle 872 during use of the stove 800.

Venting Door

Fig. 6 displays an embodiment of an ash drawer 114 and venting door 280. In a closed position, the ash drawer 144 may be adjacent to the venting door 280. The venting door 280 may be generally rectangular shaped with a length and curve similar to a length of the outside surface 270 of the ash drawer 114. When assembled, the venting door 280 may be connected to the outer body 116 by a hinge 282. When the venting door 280 is closed, it has an inner surface 284 that may mate against the outer body 116 of the stove 100 and the tabs 268 of the ash drawer 114.

The venting door 280 may comprise a locking mechanism 286, which stabilizes the venting door 144 in a closed position, and thereby secures the ash drawer 114 within the interior portion of the air intake chamber 110 when the locking mechanism is engaged 286. In some examples, the locking mechanism 286 may have a rotatable lever arm that may be positioned between a tab and the body 116 of the stove 100, 800. The engaged locking mechanism 286 and the ash drawer tabs 268 help to prevent the removal of the ash drawer 114 from the stove 100 when the venting door 280 is shut. The plurality of tabs 268 mounted on the inside surface 276 of the front section 274 of the drawer 114 may contact the inner surface 284 of the venting door 280 which prevents the ash drawer 114 from being removed when the door 280 is shut, since the locking mechanism 286 prevents the door 280 from being opened, thereby preventing the drawer 114 from being removed. This feature may help consumers when moving the stove 100 to different locations so that the door 280 does not accidentally open and the drawer 114 is not accidentally removed or ejected.

In some examples, the venting door 280 further comprises a set of apertures 287 formed through the venting door 280 that acts as vents to allow air to flow into the stove 100 when the door 280 is in a closed position. In some examples, the apertures 287 may be oval shaped, with a length that is generally normal to the length of the top surface 262 of the ash drawer 114. In many embodiments, the venting door 280 further comprises a vent slide 288 with apertures 290 formed therethrough that mimic the shape of the apertures 286 formed in the door 280. The vent slide 288 may be positioned proximal the inner surface 284 of the venting door 280 and allowed to slide horizontally relative the venting door 280 by an integrally formed upper bracket and a lower bracket. The upper bracket and a lower bracket control the movement of the vent slide 288 to a single degree of freedom so that the vent slide 288 may slide back and forth within the upper bracket, lower bracket and against the inner surface 284. This slidable connection may allow for the position of the vent slide 288 to be adjusted such that the when vent slide apertures 290 are aligned with the vent door apertures 287, the maximum air intake into the stove 100 with the vent door 280 in a closed position is achieved. The slidable connection may also allow for the vent slide 288 to be adjusted so that the vent door apertures 287 are partially or substantially blocked to decrease or block the fresh air allowed into the stove 100. This allows a consumer to control the air fuel ratio. In many embodiments, the vent slide 288 may comprise a tab 292 that allows the user to slidably adjust the position of the vent slide 288 compared to the venting door apertures 287.

In some examples, as shown in Fig. 8, the tab 292 may have protective cover or guard 877 to protect a user from the potentially increased temperature of the tab 292 while the stove is in use. In some examples, the locking mechanism 286 may also have a grip 879 to similarly protect a user from heat transferred to the locking mechanism 286, and to also enhance the user's grip on the locking mechanism 286.

Assembly

The upper combustion chamber 104 may mate with the lower combustion chamber 106 through welding, riveting or other connection methods to form the upper internal section 102. It is also contemplated that the upper combustion chamber 104 and the lower combustion chamber 106 are integrally formed. The grate 118 may be permanently installed within the upper internal section 102. The lower combustion chamber 106 may mate with the air intake chamber 110 through welding, riveting, or other connection methods. In some examples, the outer body 116 may be formed using rolled metal that is welded, riveted or otherwise connected. The assembled upper combustion chamber 104, lower combustion chamber 106, and air intake chamber 110 may be installed within the outer body 116.

The inlet 200 to the air intake chamber 110 may be installed adjacent the stove inlet 140. The stove inlet 140 may be defined in the cylindrical portion of the outer body 116 and positioned at or near the bottom 120 of the outer body 116. The cooktop 112 may be positioned at the upper portion of the outer body 116. In many embodiments, insulation may be positioned between the inner surface 138 of the outer body and the outer surfaces of the upper internal section 102 and the lower internal section 108. Insulation is not pictured in Fig. 2, but would be positioned to line the cavity 142 formed by the inner surface 138 of outer body, the cooktop 112, the upper internal section 102 and lower internal section 108. The insulation may be of various materials, including aluminum silicate blanket, ceramic type insulation or other high temperature insulation. Insulation can be placed in the cavity 244 formed by the subfloor 246 and the bottom 120 of the outer body 116. The placement of insulation may help prevent the supporting surface from heat damage.

Conclusion

All directional references (e.g., upper, lower, upward, downward, left, right, leftward, rightward, top, bottom, above, below, inner, outer, vertical, horizontal, clockwise, and counterclockwise) are only used for identification purposes to aid the reader's understanding of the example of the invention, and do not create limitations, particularly as to the position, orientation, or use of the invention unless specifically set forth in the claims. Joinder references (e.g., attached, coupled, connected, joined, and the like) are to be construed broadly and may include intermediate members between a connection of elements and relative movement between elements. As such, joinder references do not necessarily infer that two elements are directly connected and in fixed relation to each other.

In some instances, components are described with reference to "ends" having a particular characteristic and/or being connected with another part. However, those skilled in the art will recognize that the present invention is not limited to components which terminate immediately beyond their points of connection with other parts. Thus, the term "end" should be interpreted broadly, in a manner that includes areas adjacent, rearward, forward of, or otherwise near the terminus of a particular element, link, component, part, member or the like. In methodologies directly or indirectly set forth herein, various steps and operations are described in one possible order of operation, but those skilled in the art will recognize that steps and operations may be rearranged, replaced, or eliminated without necessarily departing from the spirit and scope of the present invention. It is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative only and not limiting. Changes in detail or structure may be made without departing from the spirit of the invention as defined in the appended claims.

CLAIMS

We claim:

1. A biomass stove comprising an outer body, a cooktop, an upper internal section, and a lower internal section.
2. The biomass stove of claim 1, wherein the upper internal section comprises an upper combustion chamber, a lower combustion chamber, and a grate.
3. The biomass stove of claim 2, wherein the upper combustion chamber is substantially cylindrically shaped and the lower combustion chamber is conically shaped with a larger diameter adjacent to the upper combustion chamber.
4. The biomass stove of any one of claims 1-3, wherein the lower combustion chamber has a height and an angle optimized with the larger diameter to minimize the loss of radiant heat that originates in the lower combustion chamber and is directed out of an inlet of an air intake chamber.
5. The biomass stove of any one of claims 1-4, wherein the lower combustion chamber has an inlet with an optimized smaller diameter to minimize the heat directed towards the inlet and maximize the heat reflected from an inside surface of the lower combustion chamber and up towards the upper combustion chamber.
6. The biomass stove of any one of claims 1-5, wherein the larger diameter creates an optimized large fuel bed to increase the overall heating capacity of the stove.
7. The biomass stove of any one of claims 1-6, further comprising

   an ash drawer, and

   wherein the outer body comprises a venting door and a locking mechanism that engages with the ash drawer to secure the ash drawer within the stove when the locking mechanism is engaged.
8. The biomass stove of claim 7, wherein when the ash drawer is secured, a bottom surface of the drawer is located inside of the lower internal section of the stove.
9. The biomass of any one of claims 1-8, wherein the outer body comprises a venting door with apertures for air to flow into the stove, the venting door further comprising a vent slide with apertures for air to flow into the stove that is adjustably connected to the venting door, and the adjustment of the vent slide apertures relative to the venting door apertures adjusts the air flow into the stove.

10. The biomass stove of any one of claims 1-9, further comprising an ash drawer having a handle, wherein the drawer may be removed from the stove by the handle and used to fan an inlet of an air intake chamber to increase air flow into the stove at startup.

11. The biomass stove of any one of claims 1-10, wherein the lower internal section comprises an air intake chamber with an inlet, an outlet, a top segment, a bottom segment, a first side segment, a second side segment and a rear segment.

12. The biomass stove of claim 11, wherein the bottom segment, first side segment, second side segment and a bottom of the upper body form a bottom cavity wherein insulation is placed, and the insulated bottom cavity prevents heat damage to a supporting surface where the stove is placed.

13. The biomass stove of any one of claims 1-12, wherein the cooktop comprises a drip pan.

14. The biomass stove of claim 13, wherein the drip pan comprises a combustion chamber outlet, a plurality of pot supports extending from an upper surface, a drip pan lip, a drip pan reservoir, and a plurality of slotted tabs that extend from a lower surface, wherein the drip pan lip is elevated vertically above the drip pan reservoir and configured to direct a liquid away from the combustion chamber outlet.

15. The biomass stove of any one of claims 1-14, wherein the outer body further comprises a plurality of legs, and each leg is formed by the outer body and an internal foot guide that compress a rubber foot so the stove can be used on a supporting surface without damage to the supporting surface.

16. A method for manufacturing a biomass stove comprising:
forming from metal an outer body, an upper section with an upper combustion chamber and a lower combustion chamber, and a lower section with an air intake chamber;
casting a cook top with a drip pan; and
assembling the outer body, upper section, lower section and cook top.

17. The method of claim 16, wherein the upper combustion chamber is substantially cylindrically shaped and the lower combustion chamber is substantially conical shaped.

18. The method of any one of claims 16-17, wherein the air intake chamber is formed by three pieces of metal.

19. The method of any one of claims 16-18, wherein the upper combustion chamber and lower combustion chamber are integrally formed.

20. A biomass stove comprising:

an outer body;

a cooktop;

an upper internal section;

a lower internal section;

an ash drawer;

wherein an outer cavity is formed by the upper internal section, the lower internal section, the outer body and the cooktop, and an insulating material is placed within the outer cavity;

wherein the outer body comprises a bottom, a venting door, a plurality of handles and a plurality of legs, wherein each leg is formed by rubber foot compressed between the outer body and an internal foot guide;

wherein the venting door comprises a hinge, an inner surface, a locking mechanism, apertures, a vent slide, an upper bracket and a lower bracket, wherein the vent slide comprises apertures and a tab,

wherein the cooktop comprises a drip pan, a combustion chamber outlet, a plurality of pot supports, a drip pan lip, a drip pan reservoir, a plurality of drip pan tabs, and a lower surface;

wherein the upper internal section comprises an upper combustion chamber, a lower combustion chamber, and a grate;

wherein the upper combustion chamber is substantially cylindrical;

wherein the lower combustion chamber is conically shaped and has an inlet;

wherein the upper combustion chamber and lower combustion chamber are joined and the grate is located at the joined location;

wherein the grate and the upper combustion chamber create a fuel bed;

wherein the lower internal section comprises an air intake chamber with an inlet, an outlet, a top segment, a bottom segment, a first side segment, a second side segment, and a rear segment;

wherein the top segment of the air intake chamber comprises a flat region, a first flange and a second flange;

wherein the first side segment of the air intake chamber comprises a flange and an inside surface;

wherein the second side segment of the air intake chamber comprises a flange and an inside surface;

wherein the bottom segment of the air intake chamber comprises a top surface, a flat region, a first flange, and a second flange;

wherein a bottom cavity is formed by the flat region of the bottom segment, the first side segment, the second side segment, and the bottom of the outer body;

wherein the ash drawer has a first side section, a second side section, a front section with an inside surface and outside surface, a bottom surface, a handle, and a plurality of tabs.

21. The biomass stove of any one of claims 1, 2, or 20, wherein the grate is permanently mounted within the upper internal section.

22. The biomass stove of any one of claims 1, 7, 8, or 20, wherein the locking mechanism has a rotatable lever arm that can be rotated to fit between a tab and the outer body of the stove.

23. The biomass stove of any one of claims 1, 9, or 20 wherein the vent slide is positioned proximal to an inner surface of the venting door and allowed to slide horizontally relative the venting door by an upper bracket and a lower bracket, wherein the upper bracket and lower bracket are integrally formed with the venting door.

24. The method of any one of claims 16, 17, 18 or 19, wherein forming the outer body comprises rolling a sheet of metal into a cylindrical shape and riveting a first end and a second of the sheet together.

25. The method of any one of claims 16, 17, 18, 19, or 24, further comprising forming a plurality of handles; and

mounting the plurality of handles on an exterior surface of the outer body.

26. The method of any one of claims 16, 17, 18, 19, 24, or 25, further comprising forming an ash drawer, a venting door, and a vent slide from metal.

27. The method of any one of claims 16, 17, 18, 19, 24, 25, or 26 wherein forming the ash drawer, the venting door, and the venting slide further comprises encasing a portion of the ash drawer and the venting slide in a grip.

28. The method of any one of claims 25, 26, or 27, wherein forming the plurality of handles further comprises encasing a portion of each handle in a grip.

29. The biomass stove of any one of claims 13 or 14, wherein the plurality of pot supports are elevated vertically above the drip pan lip.

30. The biomass stove of any one of claims 13, 14, or 27, further comprising a second set of pot supports that extend vertically upwards from an outer edge of the cook top.

31. A method of using the biomass stove of any of the preceding claims, comprising

installing a fuel bed onto the grate;

igniting the fuel bed;

adjusting the position of the vent slide with reference to the venting door to adjust the air flow into the stove;

positioning a cooking vessel adjacent the pot supports of the cooktop to allow the ignited fuel bed to heat the cooking vessel.

32. The method of claim 31, further comprising

grasping the handle of the ash drawer and removing the ash drawer from the stove; and

moving the ash drawer in a repeated motion to increase air flow into the stove.

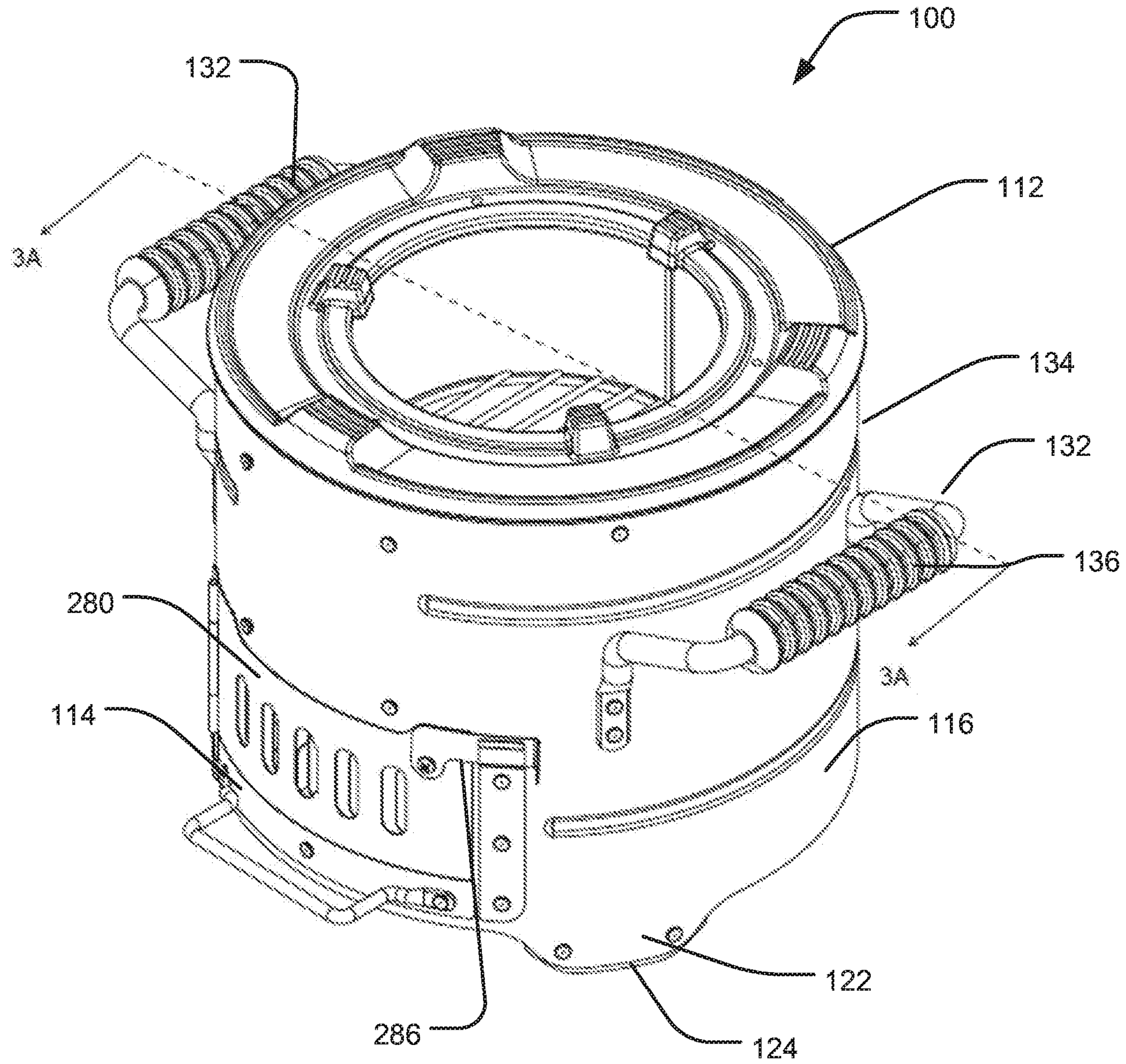

Fig. 1

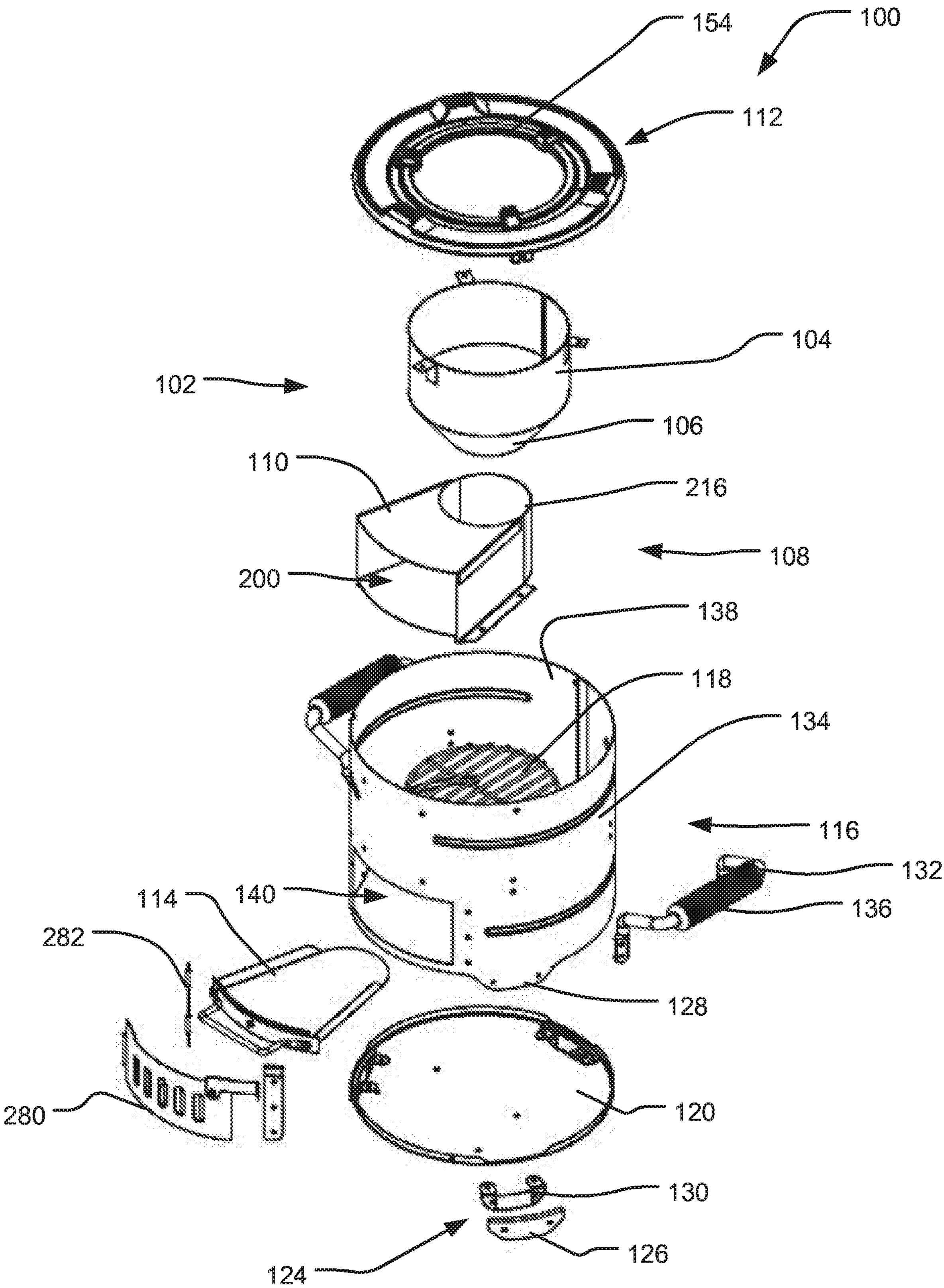
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Fig. 2

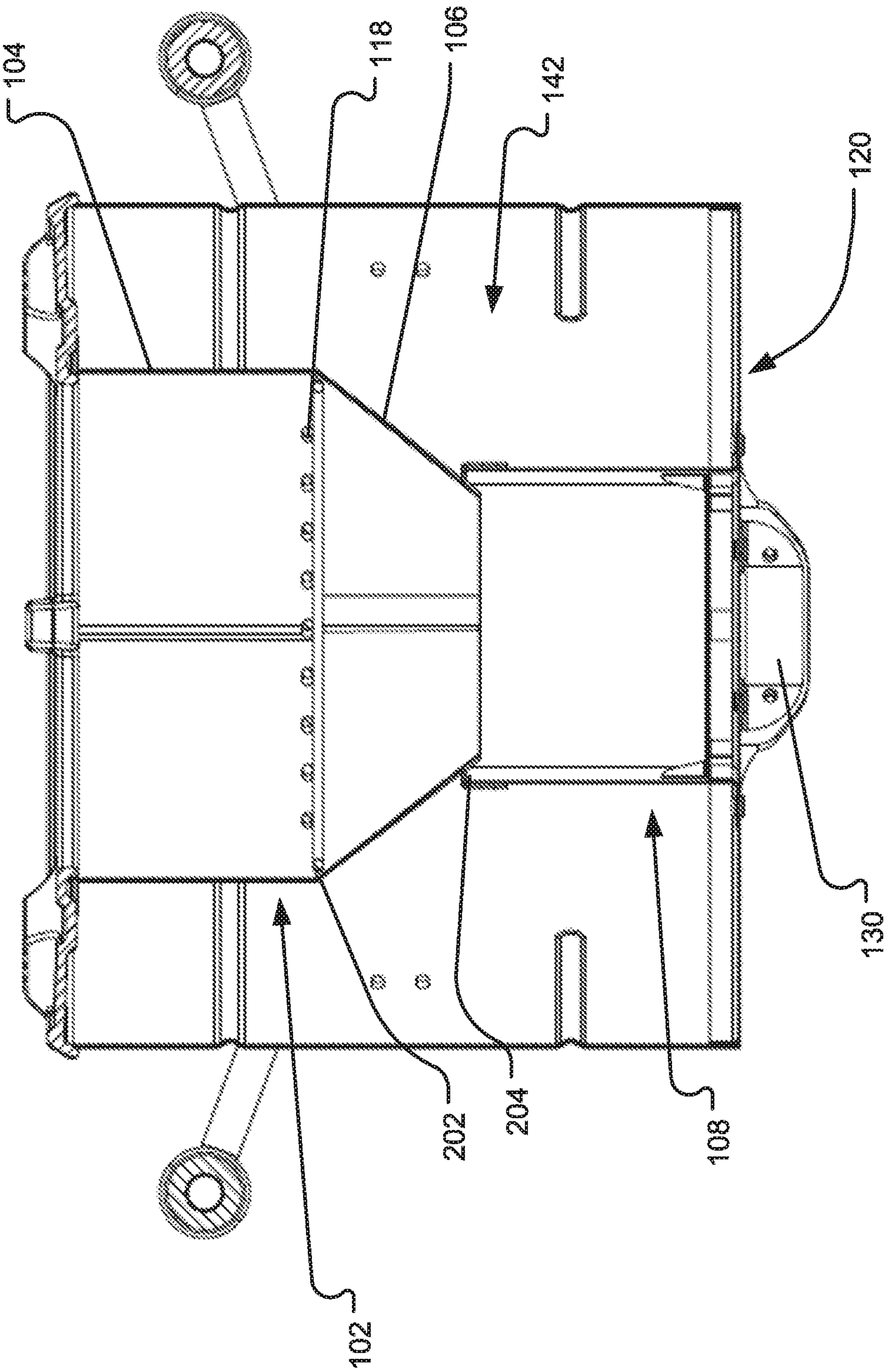

Fig. 3A

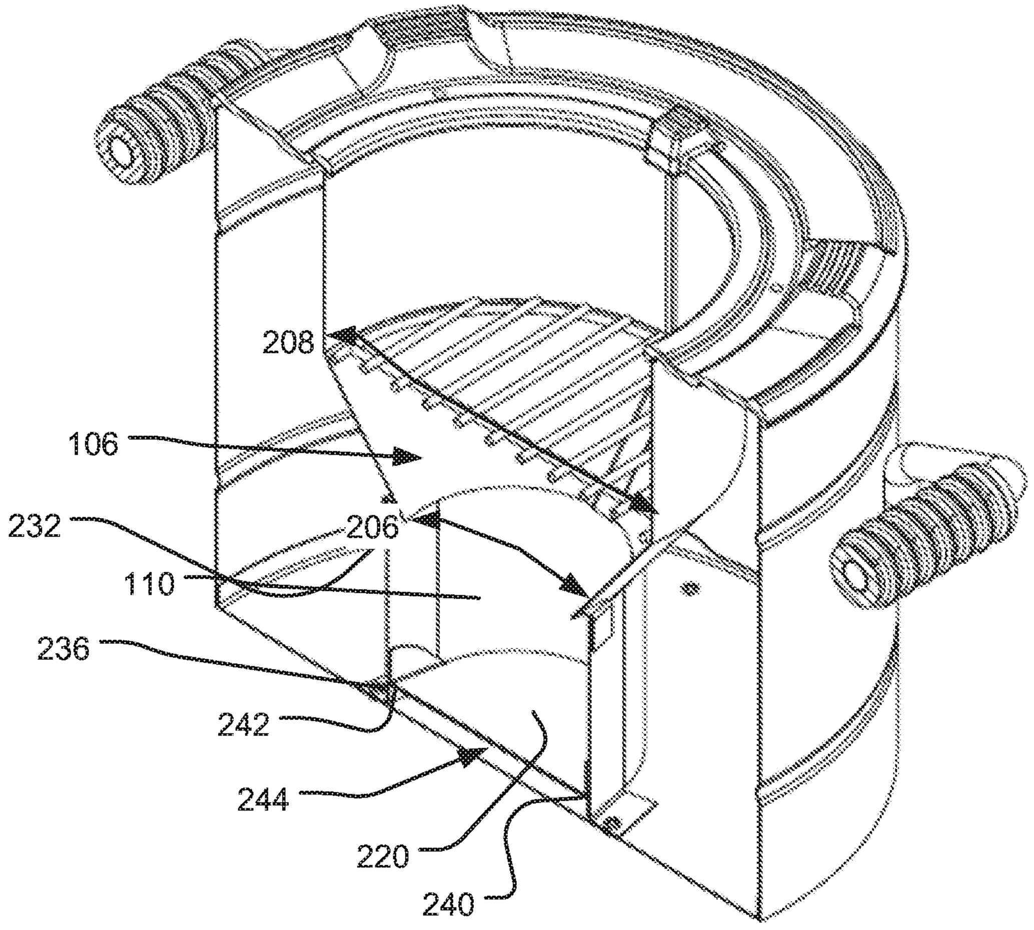

Fig. 3B

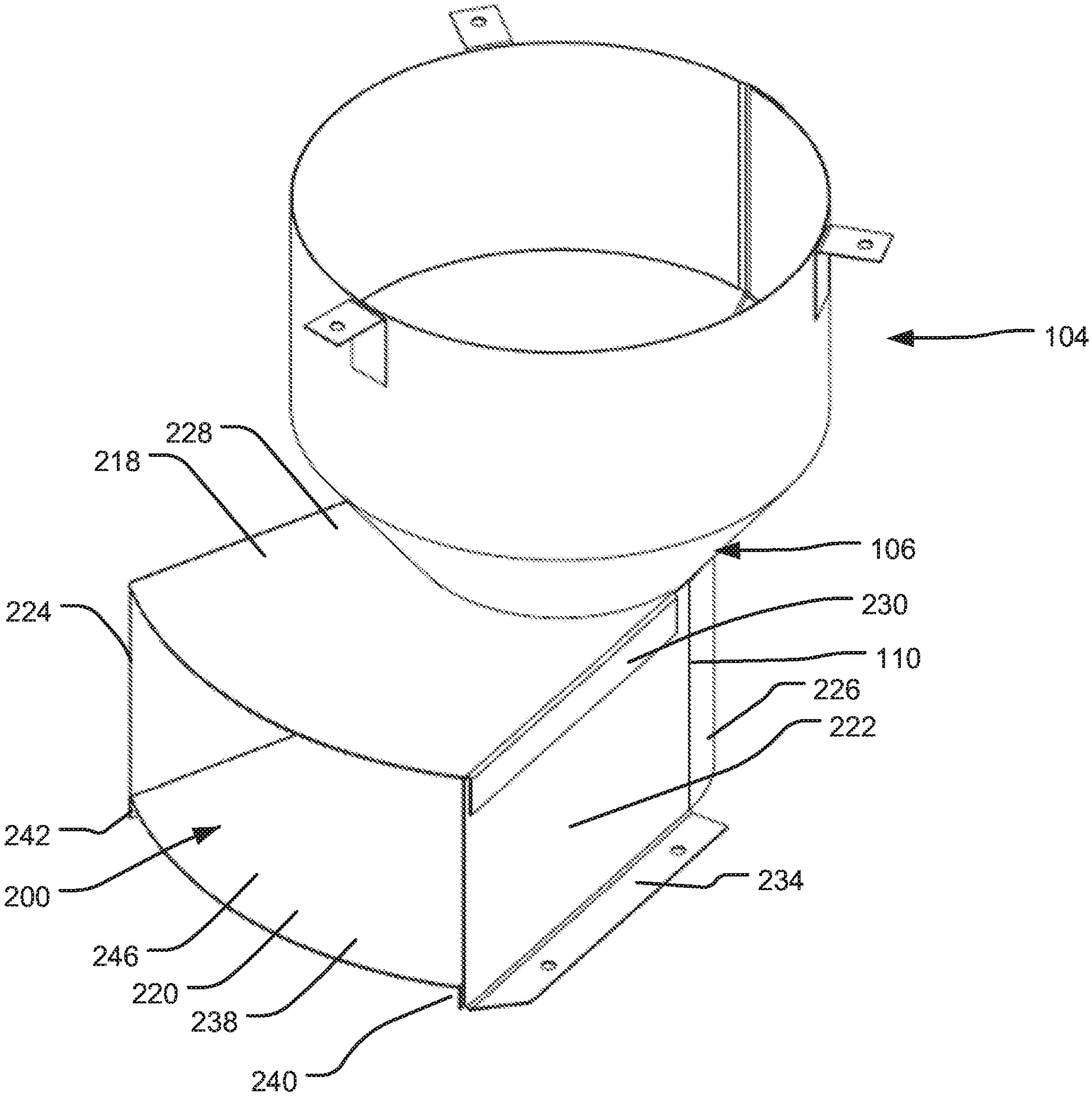

Fig. 4A

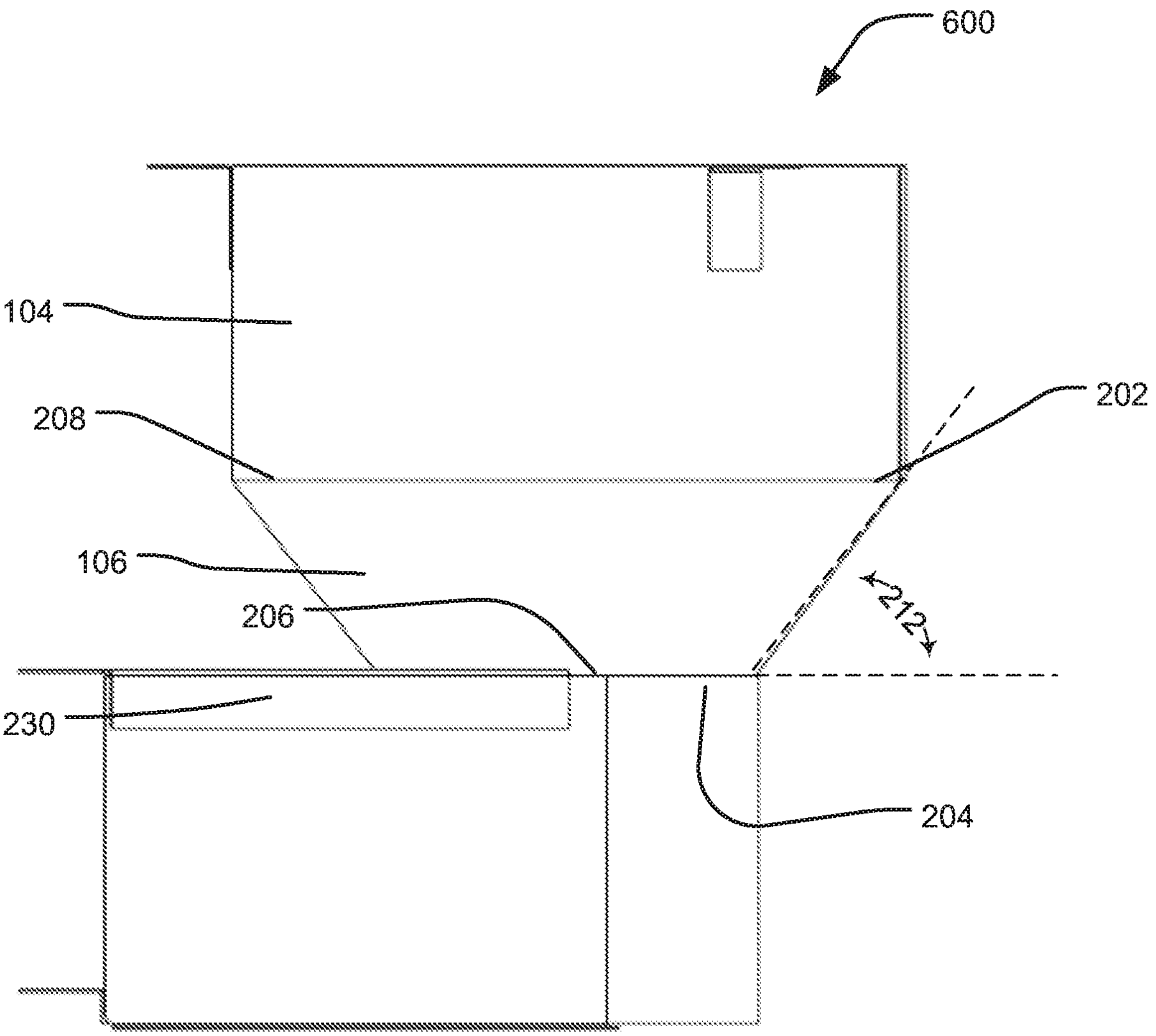

Fig. 4B

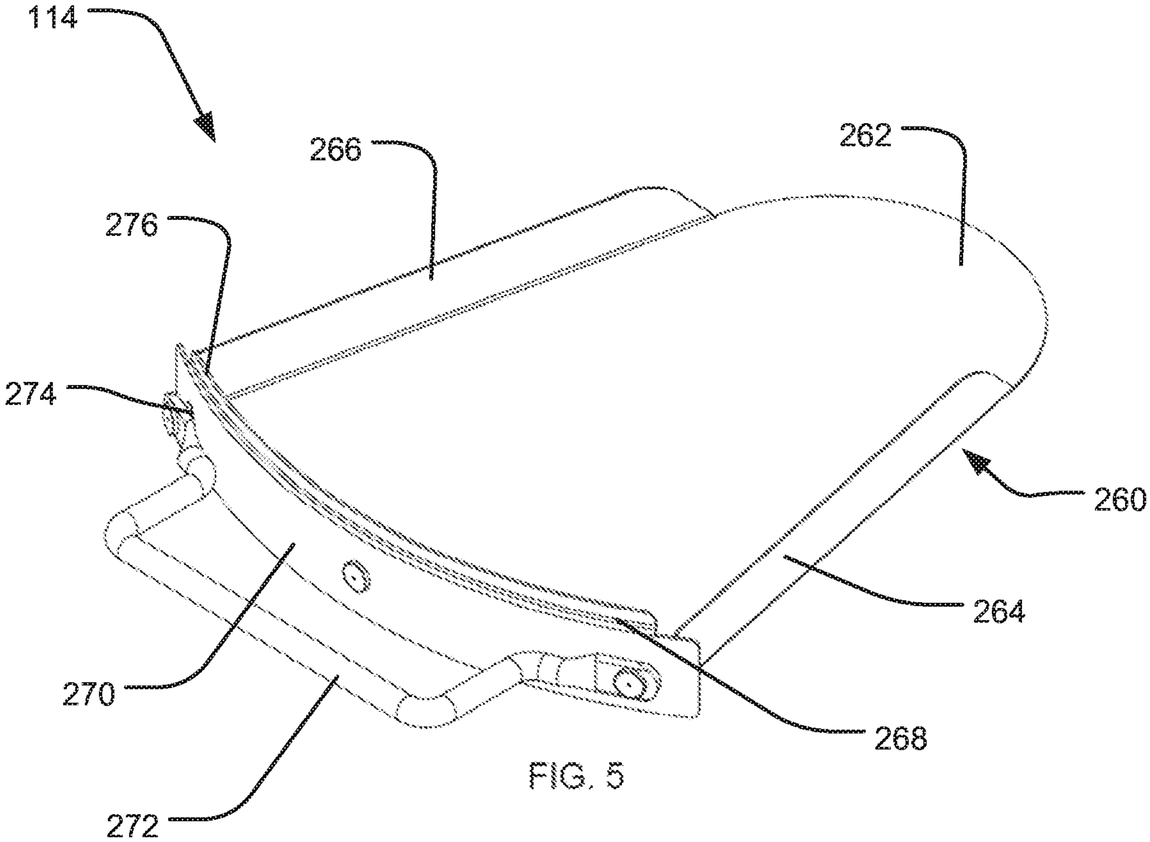

FIG. 5

Fig. 5

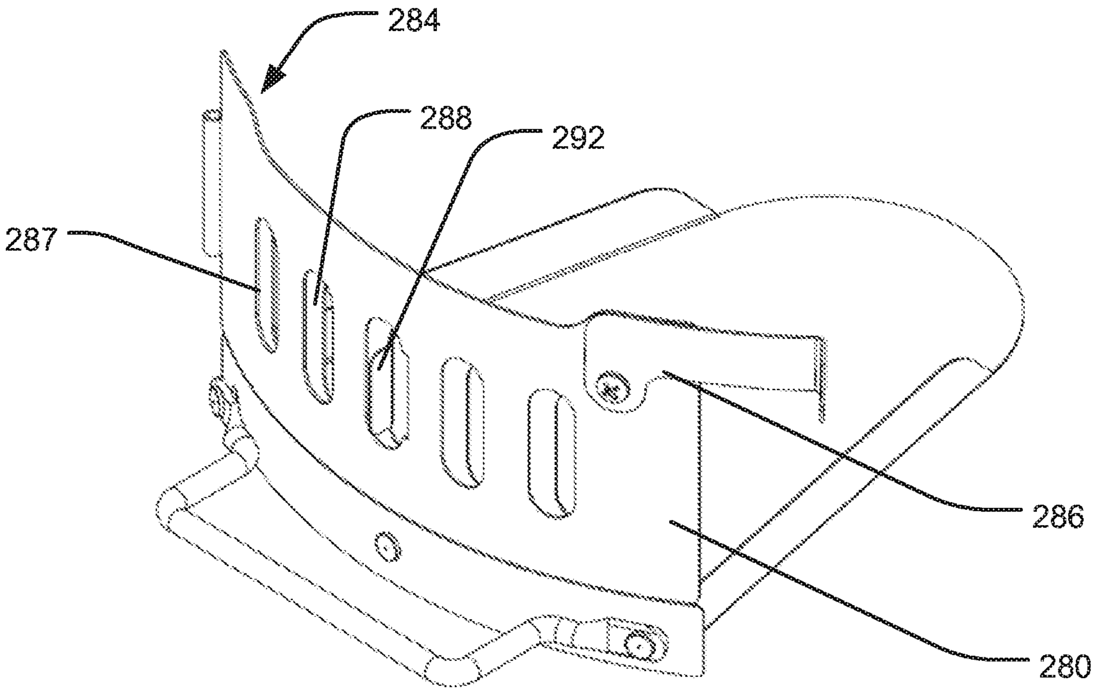

Fig. 6

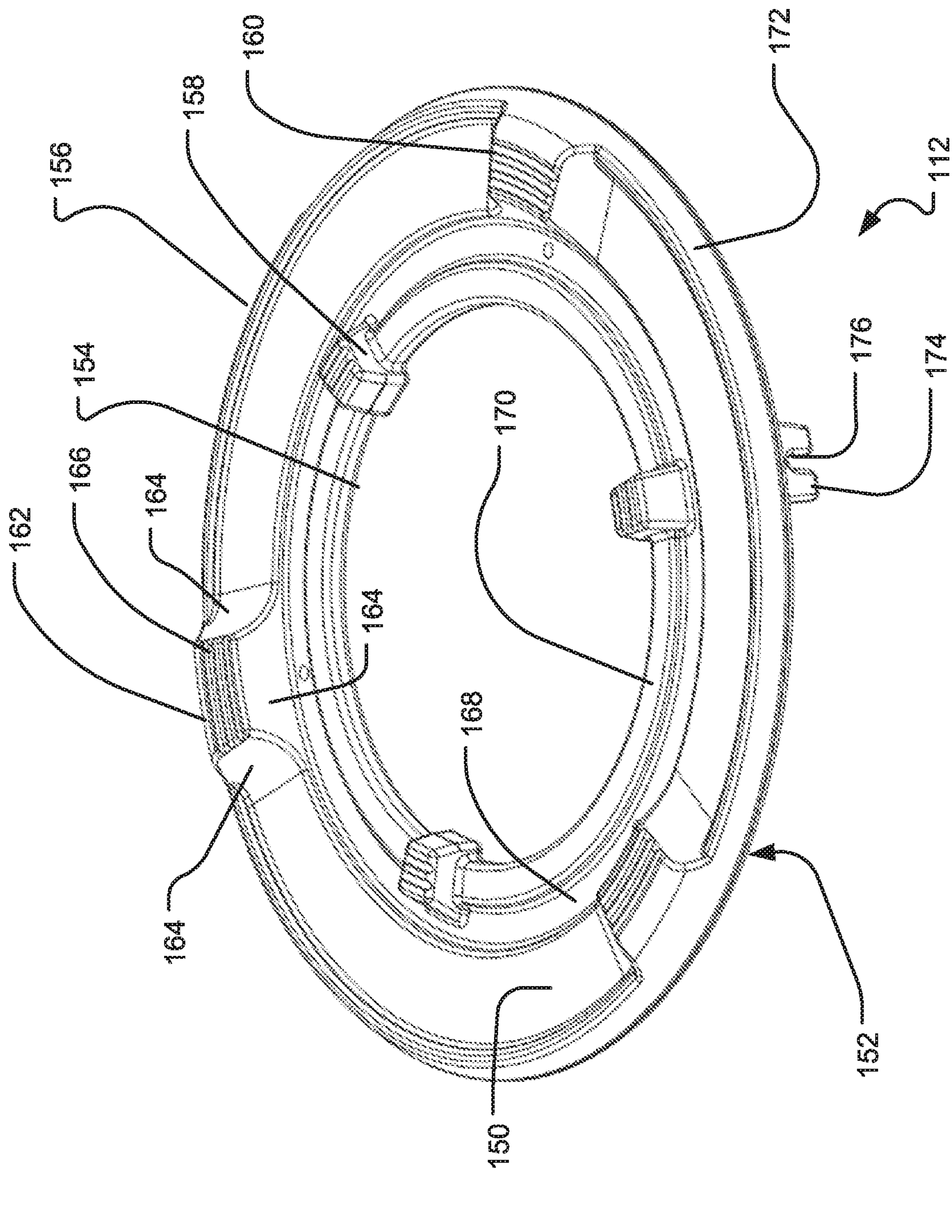

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Fig.7

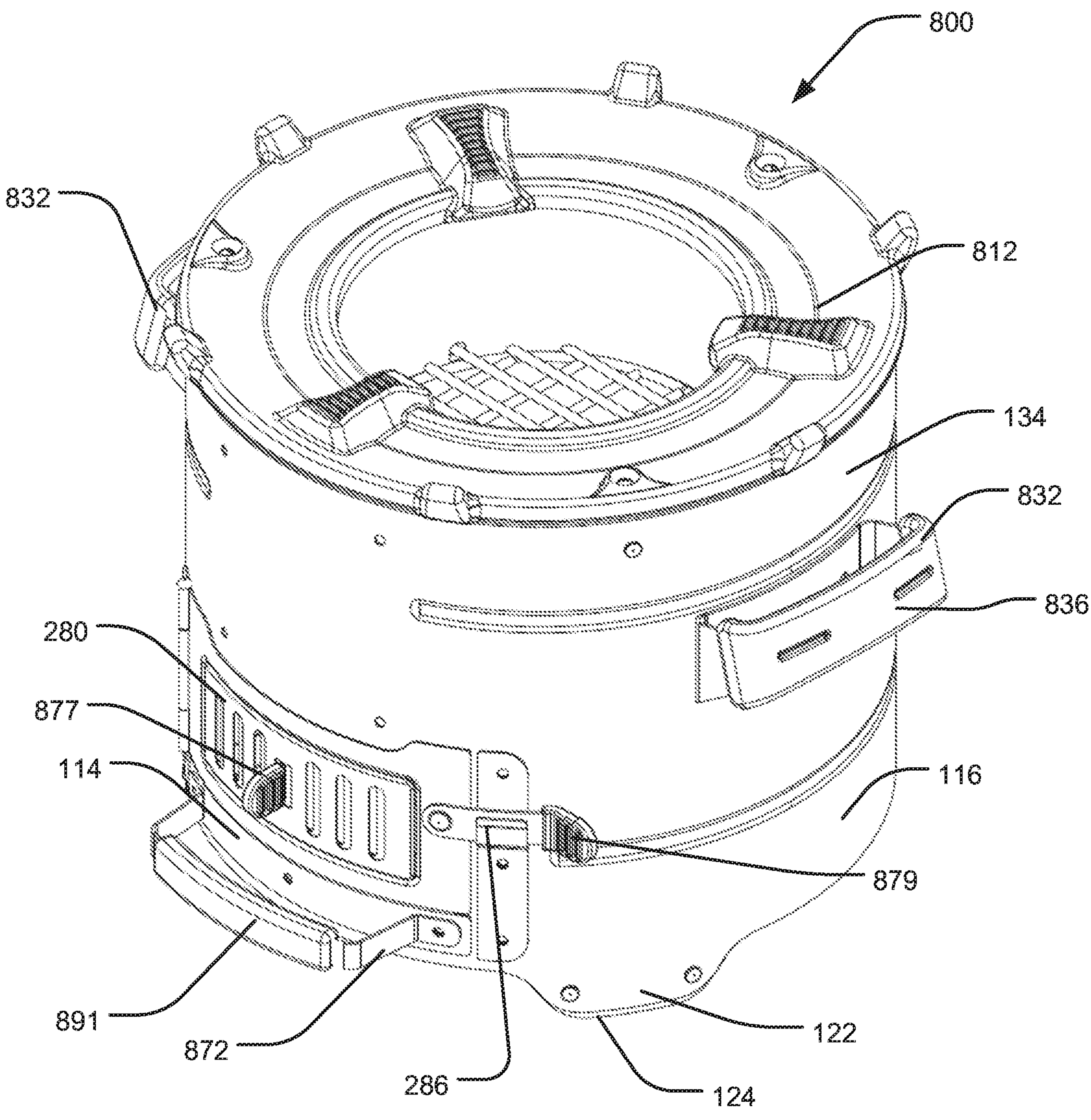

Fig. 8

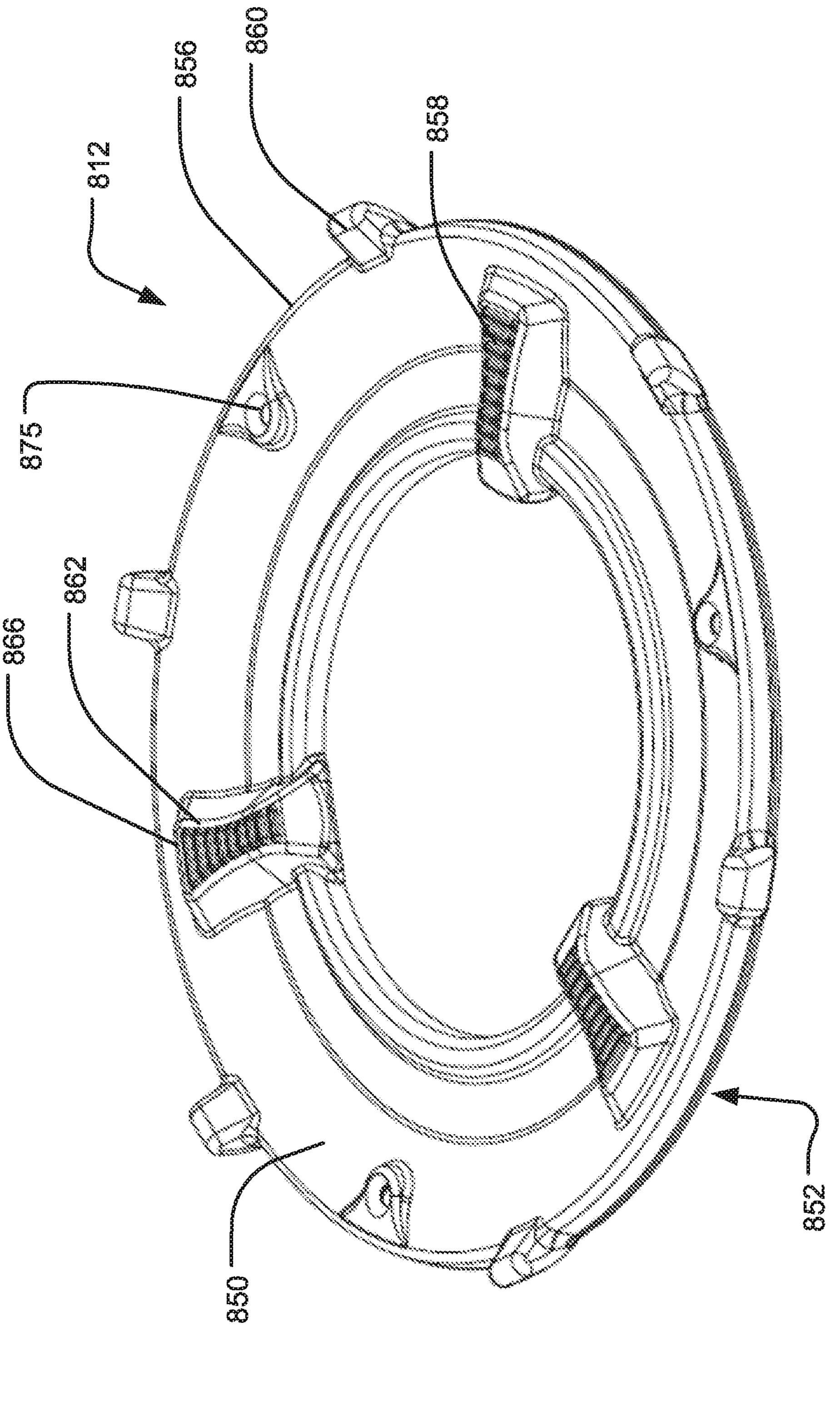

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/60794

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F24B 1/02, 1/191, 1/26, 1/28 (2016.01)
CPC - F24B 1/02, 1/191, 1/26, 1/28
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)
IPC(8) Classifications: F24B 1/02, 1/191, 1/26, 1/28 (2016.01)
CPC Classifications: F24B 1/02, 1/191, 1/26, 1/28

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google; Google Scholar; EBSCO; IP.com; keywords: biomass, wood, coal, stove, burner, grill, grate, mesh, metal, steel, cast iron, iron, cone, conical, cast, cooktop, surface, platform

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	CN 2110792 U (WEIMIN Z) July 22, 1992; figure 1; page 2, paragraphs 1, 2	1-3, 4/1-4/3, 21/1, 21/2 --- 21/1, 21/2
X	US 238,108 B2 (GRAVES JH) February 22, 1881; figure 1; page 1, lines 25-35; page 2, lines 55-80	16, 17, 18/16, 18/17
Y	US 4,730,597 A (HOTTENROTH FW et al.) March 15, 1988; figure 2; column 5, lines 5-10; column 6, lines 25-30	21/1, 21/2
A	US 4,858,536 A (GUEST JH et al.) August 22, 1989; entire document	1-3, 4/1-4/3, 16, 17, 18/16, 18/17, 20, 21/1, 21/2, 21/20
A	US 2015/0201805 A1 (BIOLITE LLC.) July 23, 2015; entire document	1-3, 4/1-4/3, 16, 17, 18/16, 18/17, 20, 21/1, 21/2, 21/20
A	US 2011/0114074 A1 (DEFOORT MW et al.) May 19, 2011; entire document	1-3, 4/1-4/3, 16, 17, 18/16, 18/17, 20, 21/1, 21/2, 21/20

☐ 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 another 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
03 January 2017 (03.01.2017)	16 FEB 2017

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/60794

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 5-15, 19, 22-32
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report coves only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.