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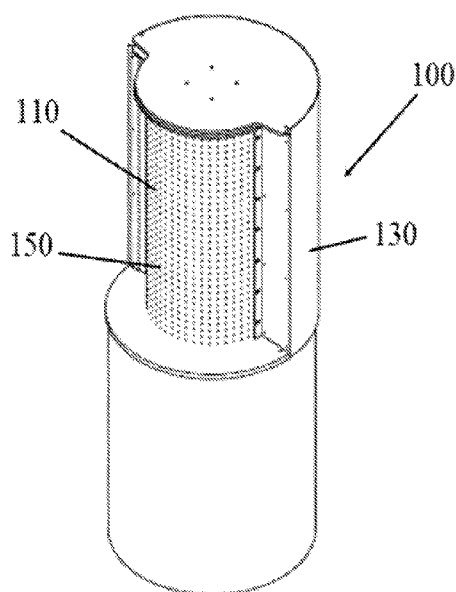


FIG. 1B

(57) **Abstract:** A drying device is provided, the device comprising a perforated support, typically a perforated plate, and a pump for forcing air through the perforated support, wherein, upon locating an object to be dried at the perforated support air passing through the perforated support passes through the object to be dried. Typically, the object to be dried is an article of clothing. Methods for drying clothing by passing air through a perforated plate are provided as well.



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DEVICE AND METHOD FOR DRYING CLOTHING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/582,692, filed November 7, 2017, the contents of which are incorporated by reference herein in their entirety.

FIELD OF THE INVENTION

[0002] The invention relates to drying clothing, particularly in a relatively short amount of time, such as those for use in homes, hotels, gyms, spas, laundromats, and other facilities. This disclosure relates to a device and method for drying clothing using forced air.

BACKGROUND

[0003] Often, people who attempt to balance many tasks while maintaining a workout routine don't have time to dry their workout clothing after exercising. This may result in returning home after a long day with wet, sweaty clothes in plastic bags provided by a gym or studio, or with dirty and sweaty gym clothing in a gym bag. In addition to remaining damp, such clothing kept in a closed bag while damp may also get moldy or otherwise damaged.

[0004] Gyms occasionally provide drying machines for members so that gym clothing can be dried after use. However, such machines are often traditional appliances designed to dry clothing and therefore take an extended period of time, and often heat clothing more than necessary. Similarly, gyms and swimming pools often provide swimsuit spinners that spin dry clothing, and which also take a significant amount of time to achieve reasonable results.

[0005] Current appliances designed to clean and dry articles of clothing include washers and dryers. A typical dryer includes a drum or closed space, which receives articles of clothing therein. Activation of the dryer causes the device to rotate (drum) while heated air is passed into and out of the device. The clothes, and more particularly,

the water content therein, is heated sufficiently to change the state of the water from a liquid to a gas (vaporization), whereupon the water vapor is ejected with the exiting airflow, which causes the clothes to become dry.

[0006] Gas dryers, which use electricity to power various electrically operated components (such as a motor, timer, buzzer alarms, lights, and other "on-board" electrical devices), are labeled as gas dryers because they use gas valves and other gas-related components to allow for heat to be generated for use in the drying process. In contrast, electric dryers do not incorporate any gas components. Instead, they use air-to-air electrical heat resistance element coils, which allow for the generation of heat to initiate the drying process.

[0007] Despite their popularity, conventional clothes dryers have a number of drawbacks. First among these is that such dryers use significant amounts of energy. This is partially a function of the extended time period associated with a drying cycle. The average full-sized 240 volt clothes dryer consumes power on the order of about 4,000 to 7,000 Watts or 90-150Wh per clothing piece. Even more, clothes dryers typically consumes energy at a higher rate than any other appliance in a home, except for the household refrigerator. This is particularly undesirable in the case of conventional gas-powered and electric clothes dryers, given the costs and environmental impact associated with consuming such energy resources.

[0008] In addition, conventional clothes dryers also fail to make efficient use of this power. The poor efficiency of conventional clothes dryers is largely due to the fact that clothes dryers simply do not use large amounts of the energy that is input to the dryers. Thermal energy put into the cycle is used for water evaporation and air temperature increase without efficient heat recovery on the gas exhaust side. Most conventional clothes dryers operate by passing dry, heated air around and through the clothes being dried, such that the clothes are heated up, and moisture within the clothes evaporates. The heated, moist air is then exhausted out of the dryer and out into the environment (typically, outside the facility housing the dryer). Given this design, clothes

dryers continuously expel, as waste, large amounts of heat energy during operation and, therefore, much of the heated air that is directed toward clothes during the drying process simply passes by the clothes and is vented out of the machine without ever contributing to the actual drying of the clothes.

[0009] Clothes dryers also waste heat energy in other ways. For example, much of the heat generated by clothes dryers simply escapes from the dryers due to a combination of radiation, conduction, and convection before the heat ever reaches the clothes. Furthermore, even to the extent that the heat generated by a clothes dryer reaches and heats the clothes, the energy is still often wasted. In particular, once the clothes drying cycle has been completed, the heat energy stored in the clothes is wasted as well, as the clothes sit idle within the machine.

[0010] Further conventional dryers are designed to hold several pounds of clothing which is in most cases not the amount that goes into the machine. With such partial load efficiencies are dropping even further resulting in more wasted energy.

[0011] Finally, conventional dryers are designed to dry over the course of an extended cycle, which typically lasts for 30 minutes to an hour. Accordingly, even if a user would like to dry a single garment, such as gym clothing, the user would need to wait for a complete cycle before retrieving dry clothing.

[0012] What is needed is a clothes drying machine that uses less energy and/or is more time or energy efficient than conventional clothes drying machines, while still providing similar drying capabilities, especially when drying a small number of clothes.

SUMMARY

[0013] The technology and advanced air control system wicks off moisture and bacteria quietly, but with speed. Ozone is implemented as a non-harmful additive antibacterial and antimicrobial element. IoT integration (the “brain”) measures data — humidity levels, usage, time, weight, speed, power, scent preference, cost-savings benefits, as well as a maintenance management system — that connects to the cloud.

[0014] While the clothing does in fact get disinfected in the wicking process alone, Ozone may be implemented as an additive antibacterial and antimicrobial element. Similarly, a cleaning product, such as a detergent, and/or fragrance may be added.

[0015] Internet of Things integration is contemplated as well. The device's processing circuitry may incorporate sensors that measures data — humidity levels, usage, time, weight, speed, power, scent preference, cost-savings benefits, as well as a maintenance management system, and may connect to a network, such as the cloud.

[0016] An apparatus is provided for drying, sanitizing, and/or deodorizing articles of clothing using a fixed porous plate to hold clothing and a pump or motor to force air through the clothing. A curved perforated metal stationary plate is provided to receive moisture-laden clothing that is held onto the plate by predetermined airflow through the clothing and plate orifices. A UV mechanism may be provided to sanitize the plate between use cycles, and airflow may be heated to improve wrinkle reduction and drying.

[0017] The size of the orifices may be calculated to be in such a range that the airflow velocity through the holes is optimized for holding the clothing onto the plate surface and drying the clothing efficiently. Air flow may be generated by an electric motor driving a centrifugal ventilator that circulates the air. A guide apparatus may be provided for controlling air through the outside channel, through the clothing and, through the plate orifices to create a closed loop for the airflow. A heating apparatus for heating air that moves through the guide apparatus may be provided, the heating apparatus may comprise an electric heating element in the airflow, an electric or thermal energy storage device in the form of a battery or thermal mass which is connected to either the 'electric grid' or other external electric power source, such as solar power. In some embodiments, the device may be provided with power storage sufficient to supplement received external power source such that, for example, 10 drying cycles can be completed with a maximum of 1 kW power draw from the external power supply.

[0018] A controller may be provided for controlling the other components of the system, including the airflow guide, the pump or motor, and the power supply. Restrictor

elements may be provided for impeding the airflow being pulled through the plate orifices whereby the orifice size in the relation to the total plate size is such that the air velocity is holding the clothing on the surface. Such restrictor elements may occlude individual orifices, or may occlude orifices as a group such that the airflow may be modified.

[0019] In some embodiments, thermal energy may be conserved using, for example, a heat or thermal wheel type heat exchanger. Heated 'exhaust' air flows through the heat exchanger which transfers the thermal energy, typically with between 85%-90% effectiveness, to the inflowing 'fresh' air coming from outside the machine. Heated 'fresh' air has a relative humidity lower than ambient airflow. Low humidity air enhances the drying principle of the clothing. Before 'fresh' air is circulated through the textile either Ozone (sanitation) or deodorizer can be injected in the airflow

[0020] It is an object of the present invention to provide an improved device for drying clothing.

[0021] Accordingly, in some embodiments, the drying device comprises a perforated support, typically a perforated plate, and a pump for forcing air through the perforated support, wherein, upon locating an object to be dried at the perforated support air passing through the perforated support passes through the object to be dried. Typically, the object to be dried is an article of clothing. However, it will be understood that a wide variety of objects may be dried using the device and methods disclosed herein.

[0022] The drying device may have a pump with at least two modes, where a first of the two modes is for positioning the objects to be dried at the perforated plate and a second mode is for drying the objects. The first mode may pump air at a first rate and the second mode may pump air at a second rate faster than the first rate.

[0023] The perforated plate is typically a curved rectangle, and may be made of stainless steel, and the perforations are openings for air to pass through. In some embodiments, the size of at least some of the openings can be varied or the openings can

be closed by at least partially occluding the corresponding openings. Typically, the openings may be varied so that the average flow velocity over the plate area is between 1 and 5 m/s with a pressure drop between 100 and 1,000 pascals.

[0024] In some embodiments, a plurality of openings adjacent the object to be dried remain fully open while a number of other openings are partially or completely occluded, such that airflow is directed through the object to be dried.

[0025] Typically, a housing would enclose both the plate and the pump, and airflow may be circulated within the housing by the pump. The drying device may further comprise a heat exchanger, and the airflow circulates through heat exchanger. The heat exchanger may be a condenser, and the condenser may remove moisture from the airflow. In some alternative embodiments, the heat exchanger may be a thermal wheel.

[0026] In some embodiments, the drying device may further comprise a heating element for heating at least one of the airflow forced through the perforated plate or the perforated plate itself.

[0027] In some embodiments, the drying device may further comprise an energy buffer for storing energy between use cycles of the device. Such an energy buffer may be thermal, mechanical, or electrochemical.

[0028] A controller may be provided for controlling a use cycle of the device. The device may further comprise a sensor, wherein the use cycle is initiated upon detection of objects to be dried by the sensor, or wherein the sensor is a moisture sensor and wherein the controller ends the use cycle upon detection that the object is dry. Additional sensors may be provided for controlling other elements of the device, such as determining perforations that should be occluded for a particular use cycle.

[0029] In some embodiments, the device may further comprise an infuser for infusing a substance into the airflow of the device. Such a substance may be a disinfectant, detergent, ozone, or a scent.

[0030] In some embodiments, the device further comprises a vibration transducer for vibrating the perforated plate. Such a transducer may be an ultrasonic vibration transducer comprising a series of piezo elements.

[0031] In some embodiments, the device may further comprise a UV light for sanitizing the perforated plate between use cycles.

[0032] A method for drying clothing may be provided as well, the method comprising receiving clothing at a perforated support and maintaining the clothing in a substantially stationary position while passing airflow through the clothing and the perforated support.

[0033] The clothing is then maintained in the substantially stationary position by the airflow passing through the clothing. The perforated support is typically a perforated plate, and the method may further comprise detecting, at a sensor, the presence of clothing or some other object to be dried at the perforated plate.

[0034] Accordingly, the method may detect, at the sensor, the presence of clothing at the perforated support and then initiate a drying cycle by increasing a velocity of the airflow. The method may then detect, at a moisture sensor, that the clothing is dry and end the drying cycle.

[0035] The method may initially maintain airflow at a first speed prior to receiving the clothing at the perforated support, the first speed being sufficient to retain the clothing at the perforated support, then determine that clothing has been located at the perforated support, and then maintaining airflow at a second speed greater than the first speed during a drying process, and then reducing the airflow to the first speed, such that the clothing can be removed from the perforated support.

[0036] In some embodiments, a substance, such as disinfectant, detergent, ozone, or scent is infused into the airflow during the drying process.

[0037] In some embodiments, the airflow may be heated at a heat exchanger prior to passing the airflow through the clothing and the perforated support. The heat exchanger may be a condenser, and the method may further comprise reducing the

moisture level of the airflow at the condenser prior to passing the airflow through the clothing and the perforated support.

[0038] The method may further comprise closing a housing in which the perforated support is located in order to initiate a use cycle.

[0039] In some embodiments, the perforated support comprises a plurality of openings through which the airflow passes, and the size of at least one of the openings can be varied, or the opening can be closed by at least partially occluding the corresponding openings. In such a method, the method may determine an average flow velocity or a pressure drop between the two sides of the perforated support, and may then open or close the at least one opening in order to maintain a defined average flow velocity or pressure drop.

[0040] The method may further comprise determining or identifying the location of clothing at the perforated support and opening the openings adjacent the clothing and at least partially occluding the openings that are not adjacent the clothing.

[0041] In some embodiments, the method further comprises sanitizing the perforated support with a UV light upon removal of the clothing from the perforated support.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] Figure 1A shows a perspective view of a drying device in accordance with this disclosure with a housing closed.

[0043] Figure 1B shows the drying device of FIG. 1A with the housing open.

[0044] Figure 2 shows an exploded view of the drying device of FIG. 1A.

[0045] Figure 3 shows a second embodiment of a drying device in accordance with the present disclosure.

[0046] Figure 4 is a flowchart illustrating a method of drying clothing.

[0047] Figures 5A-5G illustrate an alternative embodiment of the drying device in accordance with this disclosure with certain components being shown as transparent in certain figures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0048] The description of illustrative embodiments according to principles of the present invention is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description. In the description of embodiments of the invention disclosed herein, any reference to direction or orientation is merely intended for convenience of description and is not intended in any way to limit the scope of the present invention. Relative terms such as “lower,” “upper,” “horizontal,” “vertical,” “above,” “below,” “up,” “down,” “top” and “bottom” as well as derivative thereof (e.g., “horizontally,” “downwardly,” “upwardly,” etc.) should be construed to refer to the orientation as then described or as shown in the drawing under discussion. These relative terms are for convenience of description only and do not require that the apparatus be constructed or operated in a particular orientation unless explicitly indicated as such. Terms such as “attached,” “affixed,” “connected,” “coupled,” “interconnected,” and similar refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise. Moreover, the features and benefits of the invention are illustrated by reference to the exemplified embodiments. Accordingly, the invention expressly should not be limited to such exemplary embodiments illustrating some possible non-limiting combination of features that may exist alone or in other combinations of features; the scope of the invention being defined by the claims appended hereto.

[0049] This disclosure describes the best mode or modes of practicing the invention as presently contemplated. This description is not intended to be understood in a limiting sense, but provides an example of the invention presented solely for illustrative purposes by reference to the accompanying drawings to advise one of ordinary skill in the art of the advantages and construction of the invention. In the various views of the drawings, like reference characters designate like or similar parts.

[0050] The device 100, when incorporated into a housing 130, typically has a cabinet like shape with a (plexi)glass sliding door 140. Inside the module there may be a perforated stainless steel plate 110 visible to the eye. The inside ('inner module') of the perforated plate 110 is isolated from the outside of the plate and connecting to a centrifugal ventilator. In other words, air going through the perforated plate can only direct towards the ventilator. The perforated plate has orifices which can have properties to either open or close more depending on the amount of delta pressure over the orifices. In doing so, the airflow is modified in such a way most airflow will be passing through the OBJECT increasing drying performance. The inside of the plate 110 may have an electric heating element which can rapidly increase the plate temperature, hence the air passing through the plates orifices. Behind the plate 110, before entering the ventilator either Ozone/sanitizer or fragrance is injected in the airflow. Air flows through the ventilator housing and is directed to the outer side of the inner module, mixing the gas/sanitizer or fragrance with the air. The now slightly warmed, reduced relative humidity air is directed towards the front of the module and evenly distributed over the outer plate surface, completing the air cycle through the OBJECT. Once the OBJECT is considered 'dry' airflow is reduced to a point where it still 'sucks' the OBJECT on the plate but allows the user to remove the object from the plate when the glass door has been opened. After the object has been removed the glass door will close and the perforated plate will be sanitized using UV light, completing the process. The aforementioned process is called a 'cycle' and is discussed below in more detail in reference to FIG. 4. A cycle may, in some embodiments, be completed in 60 seconds or less depending on the thickness, size and material of the OBJECT. Monitoring of the temperatures, pressures and humidity takes place during the cycle assuring an optimized energy and time consumption.

[0051] In order to avoid breaker overload the system may be designed to never draw more than 1 kW power from the grid at all times. During cycle start brief peak power consumption over 1 kW is compensated using an energy storage device 180,

which can be electric (battery) or thermal storage capacitor (Stone or metal object conserving thermal energy), located somewhere in the housing 130. The storage device may then be capable of storing enough energy for continuous use of the device without drawing too much current from the power outlet in the applicable facility. A control unit may continuously monitor the 'State of Charge' of the energy storage module. All electronics may be coupled to one control module which connects to the 'cloud' ('IoT') which allows for continuous system monitoring, diagnostics and software updates if needed.

[0052] Figure 1A shows a drying device 100 in accordance with this disclosure with a housing closed. Figure 1B shows the drying device of FIG. 1A with the housing open. Figure 2 shows an exploded view of the drying device.

[0053] As shown, the drying device 100 comprises a perforated support, such as plate 110, and a pump 120 for forcing air through the perforations in the plate 110. During use, an object to be dried, such as an article of clothing, is applied to the plate 110 and is dried by airflow forced through the article of clothing and the plate. Typically, the plate 110 is substantially vertical, and the clothing is held against the plate by the force of the airflow passing through it. The pump 120 may be, for example, a motor 123 mated with a fan 126 for generating airflow through the device 100.

[0054] The plate 110 and the pump 120 are contained within a housing 130 having a door 140. The housing 130 typically provides a defined path for the circulation of airflow within the device 100, such that air pumped by the pump 120 is consistently directed through the plate 110. The door 140 of the housing 130 may be, for example, a glass sliding door such that clothing being dried is visible inside the door during a drying process.

[0055] During use, the door 140 of the housing 130 may be opened by a user, clothing to be dried may be applied to the plate 110, the door 140 may then be closed, and the pump 120 may then force air through the clothing within the housing 130 until the clothing is dried.

[0056] A controller may be provided in conjunction with a processor and/or control circuitry to control various processes implemented by the device 100. Accordingly, the controller may govern the operation of a dry cycle of the device. The controller may then monitor any feedback in the system, such as through sensors implemented in the device 100. Such a controller may be implemented in any number of forms to provide a user interface. In some embodiments, functions of the controller are accessible through buttons of a user interface 135 on the top of housing 130 of the device 100.

[0057] In some embodiments, the pump 120 may have two or more operating modes in order to generate airflow of different speeds. In such embodiments, the pump 120 operating in a first mode may force air through the plate at a first rate, with the first rate being selected to allow a user to position clothing on the plate 110. Accordingly, while the door 140 of the housing 130 is opened, the pump 120 may operate in the first mode with airflow sufficient to retain clothing against the plate 110. While the plate 110 may be arranged in a variety of orientations, the device 100 shown maintains the plate 110 in a vertical orientation. Accordingly, the first mode of the pump 120 may generate sufficient airflow to retain the clothing against the plate 110 even in implementations where the plate is positioned vertically.

[0058] The pump 120 may have a second operating mode in which the rate of airflow is increased to a rate faster than in the first mode for more efficient drying of the clothing. Accordingly, when the door 140 of the housing 130 is closed, the pump 120 may transition to the second mode.

[0059] While the plate 110 is shown as a curved rectangular plate, it will be understood that such a plate may be any of a variety of shapes, and it may be flattened as well. Similarly, the plate provided may be stainless steel, or it may be any of a number of other materials. While the device 100 is discussed in terms of a perforated plate 110, it will be understood that the perforated support may be provided in various other forms, including flexible or mesh supports.

[0060] As shown, the perforations 150 of the plate 110 are typically holes, or openings, through which the airflow passes. In some embodiments, the size of such openings 150 may be adjustable, either as a group or individually. For example, in some embodiments, at least some of the openings 150 may be closed by either partially or completely occluding such openings. In some embodiments, the openings 150 of the plate 110 are occluded in order to maintain a specified airflow velocity over the plate area, such as, for example, between 1 and 5 m/s, or in order to maintain a specified pressure drop between the two sides of the plate, such as a drop of between 100 and 1,000 pascals.

[0061] In some embodiments, some openings 150 may be completely occluded in order to more efficiently operate the device 100 to dry clothing. For example, in some embodiments a size of a usable drying surface of the plate 110 may be adjustable by occluding some openings 150. In such an embodiment, for a large number of clothing articles, all openings 150 may be open. When less clothing is provided for drying, openings 150 adjacent an edge of the plate 110 may be occluded, resulting in a smaller drying surface. In such a way, higher airflow velocity may be achieved, or the burden of the pump 120 may be reduced, thereby resulting in a more efficient drying process.

[0062] In some embodiments, sensors are provided for determining how much of the plate 110 contains clothing. The sensors may be monitored by the controller, which may then determine which openings 150, if any, should be occluded. In some embodiments, the controller may evaluate the shape and/or location of clothing applied to the plate 110, and may then occlude openings 150 that are not adjacent the clothing while maintaining openings adjacent the clothing in an open position.

[0063] The sensors described may further determine the presence of clothing and may be used to initiate a drying process only when clothing is applied, or only when clothing is applied and when the door 140 of the device 100 has been closed. Additional sensors may be implemented as well. For example, temperature and/or humidity sensors, or moisture sensors, may be implemented, and feedback from those sensors may be

leveraged by the controller in determining when to end a use cycle of the device 100. Similarly, pressure sensors may be implemented to monitor, and adjust airflow, based on the pressure drop across the plate 110.

[0064] Typically, the airflow circulated by the pump 120 is processed or treated by additional components within the housing 130. For example, the housing 130 may contain a heat exchanger 160, and the airflow may circulate through the heat exchanger. The heat exchanger 160, which may be, for example, a thermal wheel or a condenser, may heat and/or dry the airflow. Heated air, or air from which moisture has been removed, may result in more efficient drying of clothing applied to the plate 110. Similarly, the device 100 may further comprise a heating element independent of, or instead of, the heat exchanger for either directly heating airflow or for heating the plate 110.

[0065] The device 100 may further comprise an infuser for infusing a substance into the airflow. Such an infuser may be an ozone generator 170 and may generate and infuse ozone into the airflow, or may infuse the airflow with a disinfectant, a detergent, or a scent.

[0066] Additional features may be implemented as well in order to improve performance, cleanliness, or efficiency of the device 100. For example, the device 100 may further comprise an energy buffer 180 for storing energy between use cycles of the device. Such an energy buffer may be a battery for storing electrical energy or it may be a thermal, mechanical, or electrochemical battery. In some embodiments, for example, it may be a heat core 180 that is initially heated and retains heat during and across drying cycles.

[0067] In some embodiments, the device 100 may further comprise a vibration transducer, such as an ultrasonic vibration transducer, to vibrate the plate 110. Such vibration may turn moisture in clothing into microscopic droplets which are then more easily removed from the clothing using the airflow. In such an embodiment, the transducer may be a series of piezo elements arranged to vibrate the plate 110.

[0068] Further, the device 100 may incorporate systems for cleaning or sterilizing the plate 110. For example, a UV light may be incorporated into the door 140 of the housing 130 for sterilizing the plate 110 after each use cycle.

[0069] Figure 3 is a flowchart illustrating a method of drying clothing using a device such as the drying device 100 described above.

[0070] Typically, a user would first open the door 140 of the device 100 in order to insert an object for drying, such as clothing (200). This may be by pushing an activation button on top of the device 100 after which the door 140, in some embodiments a sliding glass door, opens and reveals the perforated plate 110 for holding the clothing.

[0071] While the door 140 is open, the pump 120 maintains airflow through the plate 110 at a first velocity or level (210). This airflow is typically strong enough to provide a pressure drop across the plate 110 such that when a user applies clothing to the plate 110, the clothing is retained by the airflow passing through the clothing and the plate without falling (220).

[0072] In some embodiments, the device 100 is designed to not use more power than a standard electric socket output allows (for example, in the US, some outlets may provide 110V at 15 A, resulting in a total of 1,650 W). While the standard electric output of outlets may vary, a module may be provided for buffering energy to allow heat rejection in the machine to be significantly increased, such as to leverage the equivalent of 10kW or higher on demand without exceeding the electric power outlet maximum capacity at any time. Accordingly, in such embodiments, prior to initiating a dry cycle, the unit will “heat up” by preheating or storing thermal energy in a heat core (at 205). The heat core in such a design may use a water based fluid heated to near boiling temperature using a 1 kW electric heating element, air/liquid heat exchanger, and built in circulation pump. When the heat core is preheated, the system is ready for use. In an exemplary system, such “heat up” can take 1-3 min depending on starting temperature

and ambient conditions. Such a cycle may be particularly desirable where the airflow is to be heated during use (at 247).

[0073] After the clothing is applied to the plate, a user may close the door 140 (at 230) and initiate a drying cycle. In some embodiments, the drying cycle may be initiated by either the closing of the door 140, which effectively seals the housing 130, by a sensor incorporated into the device 100, or manually by a user activating the device 100 at a user interface 135, such as by pushing a start button. In some embodiments, the user may indicate that the cycle should begin by pushing a button on the device 100 while the door is still open. In such an embodiment, the indication would initiate a dry cycle by first closing the door 140 and then proceeding with the remaining steps of the method.

[0074] In some embodiments, openings 150 in the plate 110 may be partially or completely occluded prior to initiating a dry cycle at the device 100. In such embodiments, some openings 150 may be occluded to control the airflow through the plate generally in order to adhere to some preferred airflow velocity or pressure differential across the plate. In other embodiments, openings may be occluded to more precisely focus airflow through the clothing on the plate 110. In such embodiments, the device 100 may detect or otherwise identify the location of clothing on the plate 110 and occlude openings 150 that are not obstructed by the clothing, while maintaining the openings 150 adjacent the clothing. Accordingly, most or all of the airflow in the device 100 would pass through the clothing.

[0075] In some embodiments, the location at which clothing is located may be identified by a user. For example, a portion of the plate 110 may be designated for small loads, and when a user applies only a single garment or a few articles of clothing, the user may indicate that only the designated portion of the plate 110 is occupied. In such a scenario, all openings 150 outside of the designated portion of the plate 110 may be occluded.

[0076] Once the dry cycle is initiated (at 230), the pump 120 increases the velocity of the airflow through the clothing and the plate 110 to a second level (240) in

order to facilitate drying of the clothing. This second level is typically calibrated for optimal drying. In some embodiments, additives are added to the airflow at this point (245) in order to incorporate additional cleaning features. For example, a disinfectant, detergent, ozone, or a scent, or other deodorizing agent may be applied to the airflow during this stage of the dry cycle. Similarly, if heat has been stored or generated in the system, such heat may be released (247) at this stage of the dry cycle.

[0077] Typically, during the drying process, the airflow may pass through the pump 120 and get directed to a region between the door 140 (in its closed position) and the plate 110. This may be through ducting or openings in the housing positioned to direct the airflow. In some embodiments, the door itself 140 or other parts of the housing 130 may be hollow, or may be provided with hollowed chambers, and is slotted for returning the airflow to the housing at appropriate locations. The airflow may then proceed through clothing mounted on the plate as it is drawn through the perforations in the plate 110 to enter a space within the housing. The airflow may then pass over the heat core 180 to be heated (at 247), infused with an additive (at 245), dehumidified at a condenser, or treated in some other way, and drawn back into the pump to be forced back through the plate 110. These additional steps may be done either before or after pumping the airflow. In some embodiments, several of these tasks are accomplished by a heat exchanger 160, and some of the airflow is bled off through ventilation at various points in the process in order to control relative humidity and other factors. Fresh intake air may then enter the process prior to or at the heat exchanger 160 or other heating element. The heat exchanger 160 may be, for example, a thermal wheel or a heat recovery wheel.

[0078] In some embodiments, the dry cycle may be timed and may then extend for a fixed amount of time and end when the cycle time is exhausted. In other embodiments, a sensor, such as a moisture or humidity sensor, may be incorporated to determine when the clothing is dry. For example, a humidity sensor may be provided in the airflow to detect when the returning air is sufficiently reduced in humidity. In such embodiments, the device 100 may detect that the clothing is dry (250) and may then

reduce the air flow to the first level (260). A user may then open the door 140 of the housing 130 (at 270), or the housing may open automatically, and remove the clothing (280).

[0079] In some embodiments, after the clothing is detected to be dry (at 250) but before ending the cycle and reducing air flow (at 260), the device 100 may implement a sanitizing stage by, for example, injecting ozone gas into the airstream and circulating it for a period of time (at 255). Ozone could then be used to kill most bacteria and eliminate odor.

[0080] In some embodiments, after each dry cycle is complete, the door 140 closes and the device 100 may sanitize the plate (290). This may be, for example, by way of a UV light incorporated into the door 140 of the device 100. Further, in systems where all relevant features are implemented, while the unit is sanitizing, the device 100 may prepare for the next usage by beginning to pre-heat the system (at 205) in preparation for the next cycle. Once this cycle is completed, the door 140 may reopen (at 200) to allow a user to initiate the following cycle.

[0081] While the present invention has been described at some length and with some particularity with respect to the several described embodiments, it is not intended that it should be limited to any such particulars or embodiments or any particular embodiment, but it is to be construed with references to the appended claims so as to provide the broadest possible interpretation of such claims in view of the prior art and, therefore, to effectively encompass the intended scope of the invention. Furthermore, the foregoing describes the invention in terms of embodiments foreseen by the inventor for which an enabling description was available, notwithstanding that insubstantial modifications of the invention, not presently foreseen, may nonetheless represent equivalents thereto.

What is claimed is:

1. A drying device comprising:
a perforated support; and
a pump for forcing air through the perforated support;
wherein, upon locating an object to be dried at the perforated support, air passing through the perforated support passes through the object to be dried.
2. The drying device of claim 1, wherein the perforated support is a perforated plate.
3. The drying device of claim 2, wherein the pump has at least two modes, and wherein in a first of the two modes, air is pumped through the perforated plate at a first rate, and in a second of the two modes, air is pumped through the perforated plate at a second rate faster than the first rate, and wherein the first mode is for positioning the objects to be dried at the plate and the second mode is for drying the objects.
4. The drying device of claim 2, wherein the plate is a curved rectangle.
5. The drying device of claim 2, wherein perforations of the perforated plate are openings through which air passes.
6. The drying device of claim 5 wherein a size of at least one of the openings can be varied or the opening can be closed by at least partially occluding the corresponding opening.
7. The drying device of claim 6 wherein a size of a plurality of the openings is varied so that the average flow velocity over the plate area is between 1 and 5 m/s with a pressure drop between 100 and 1,000 pascals.
8. The drying device of claim 6 wherein a plurality of the openings is at least partially occluded while a plurality of openings adjacent the object to be dried remains fully open.
9. The drying device of claim 2, wherein the plate is stainless steel.
10. The drying device of claim 2 further comprising a housing enclosing the plate and the pump.

11. The drying device of claim 10, wherein airflow is circulated within the housing by the pump.

12. The drying device of claim 11 further comprising a heat exchanger, wherein the airflow circulates through the heat exchanger.

13. The drying device of claim 12 wherein the heat exchanger is a condenser, and wherein the condenser removes moisture from the airflow.

14. The drying device of claim 12 wherein the heat exchanger is a thermal wheel.

15. The drying device of claim 2 further comprising a heating element for heating at least one of the airflow forced through the perforated plate or the perforated plate.

16. The drying device of claim 2 further comprising an energy buffer for storing energy between use cycles of the device.

17. The drying device of claim 16 wherein the energy buffer is thermal, mechanical, or electrochemical.

18. The drying device of claim 2 further comprising a controller for controlling a use cycle of the device.

19. The drying device of claim 18 further comprising a sensor, and wherein the use cycle is initiated upon detection of objects to be dried by the sensor.

20. The drying device of claim 18 further comprising a moisture sensor, and wherein the controller ends the use cycle upon detecting that the object is dry.

21. The drying device of claim 2 further comprising an infuser for infusing a substance into the airflow.

22. The drying device of claim 21, the substance comprising a disinfectant, a detergent, ozone, or a scent.

23. The drying device of claim 2 further comprising a vibration transducer for vibrating the perforated plate.

24. The drying device of claim 23, wherein the vibration transducer is an ultrasonic vibration transducer comprising a series of piezo elements.

25. The drying device of claim 1, wherein the object to be dried is an article of clothing.
26. The drying device of claim 2 further comprising a UV light for sanitizing the perforated plate.
27. A method for drying clothing, the method comprising:
receiving clothing at a perforated support; and
maintaining the clothing in a substantially stationary position while passing airflow through the clothing and the perforated support;
wherein the clothing is maintained in the substantially stationary position by the airflow passing through the clothing.
28. The method of claim 27, wherein the perforated support is a perforated plate.
29. The method of claim 27, further comprising:
detecting, at a sensor, the presence of the clothing at the perforated support, and
initiating a drying cycle by increasing a velocity of the airflow.
30. The method of claim 29 further comprising detecting, at a moisture sensor, that the clothing is dry and ending the drying cycle.
31. The method of claim 27 further comprising initially maintaining airflow at a first speed prior to receiving the clothing at the perforated support, the first speed being sufficient to retain the clothing at the perforated support;
determining that clothing has been located at the perforated support;
maintaining airflow at a second speed greater than the first speed during a drying process; and
upon conclusion of the drying process, reducing the airflow to the first speed such that the clothing can be removed from the perforated support.
32. The method of claim 27 further comprising infusing a substance into the airflow, the substance comprising a disinfectant, detergent, ozone, or scent.

33. The method of claim 27 further comprising heating the airflow at a heat exchanger prior to passing the airflow through the clothing and the perforated support.

34. The method of claim 33, wherein the heat exchanger is a condenser, and the method further comprising reducing the moisture level of the airflow at the condenser prior to passing the airflow through the clothing and the perforated support.

35. The method of claim 27 further comprising closing a housing in which the perforated support is located in order to initiate a use cycle.

36. The method of claim 27, wherein the perforated support comprises a plurality of openings through which the airflow passes, and wherein a size of at least one of the openings can be varied or the opening can be closed by at least partially occluding the corresponding opening, the method further comprising:

determining an average flow velocity or a pressure drop between the two sides of the perforated support, and opening or closing the at least one opening in order to maintain a defined average flow velocity or pressure drop.

37. The method of claim 36, further comprising determining or identifying the location of clothing at the perforated support and opening the openings adjacent the clothing and at least partially occluding the openings that are not adjacent the clothing.

38. The method of claim 31 further comprising sanitizing the perforated support with a UV light upon the removal of the clothing from the perforated support.

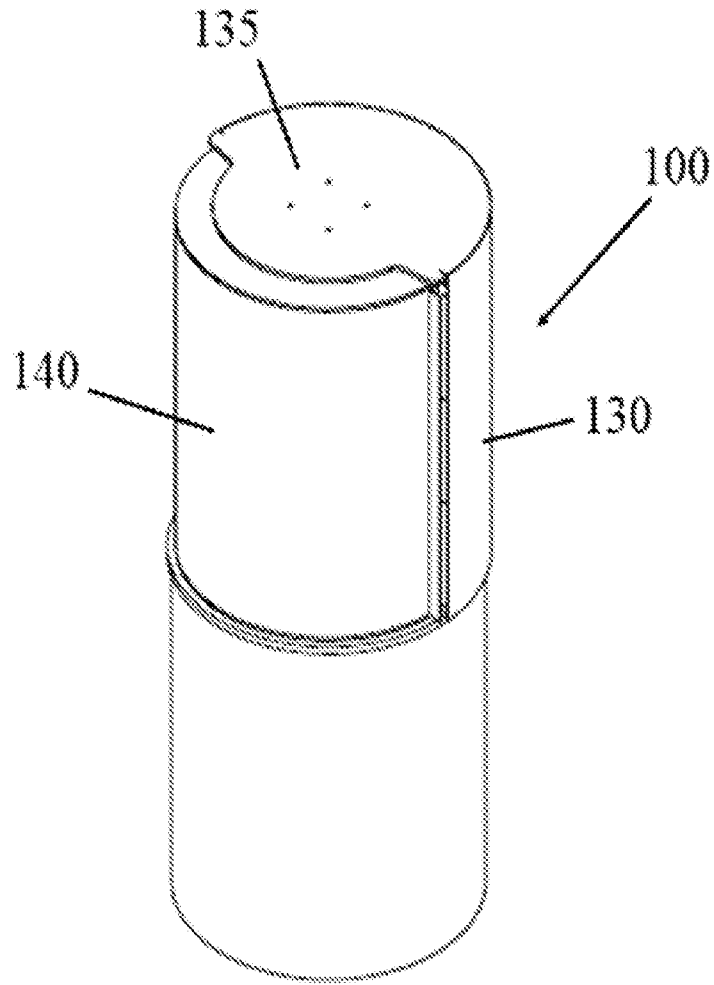


FIG. 1A

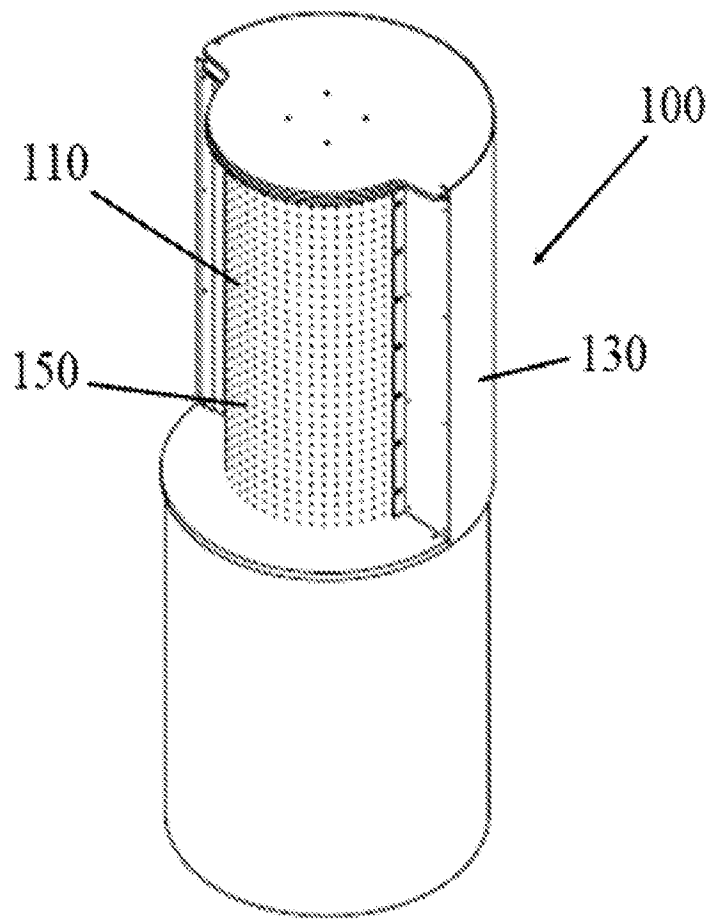


FIG. 1B

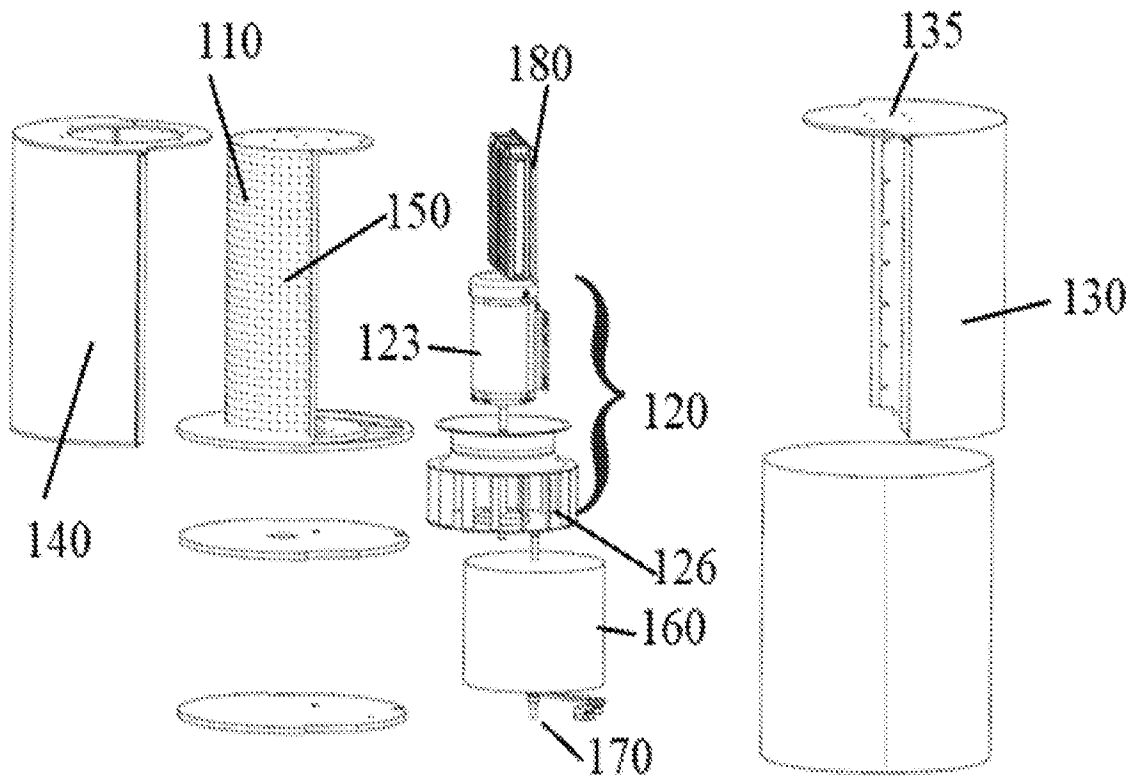


FIG. 2



FIG. 3

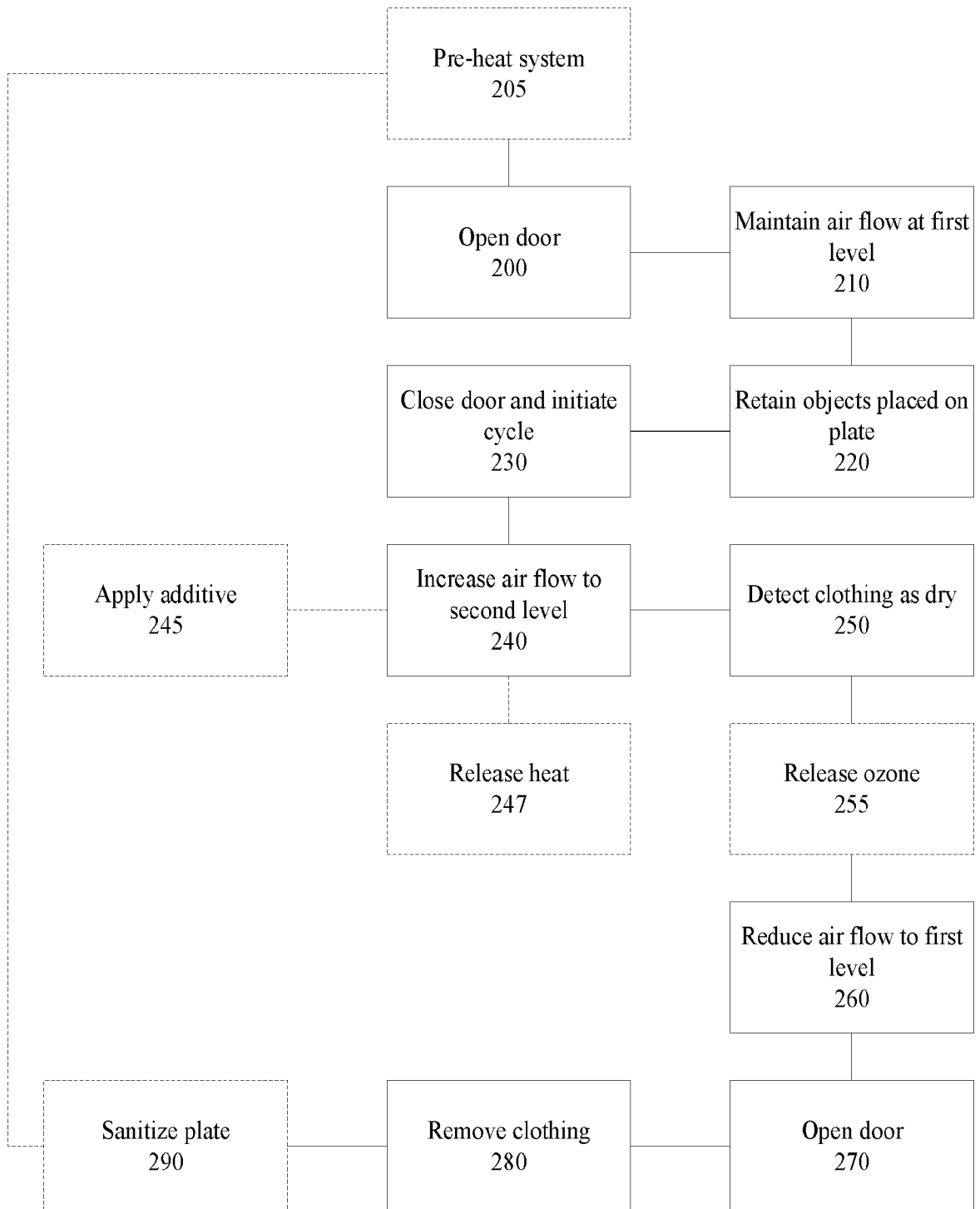


FIG. 4

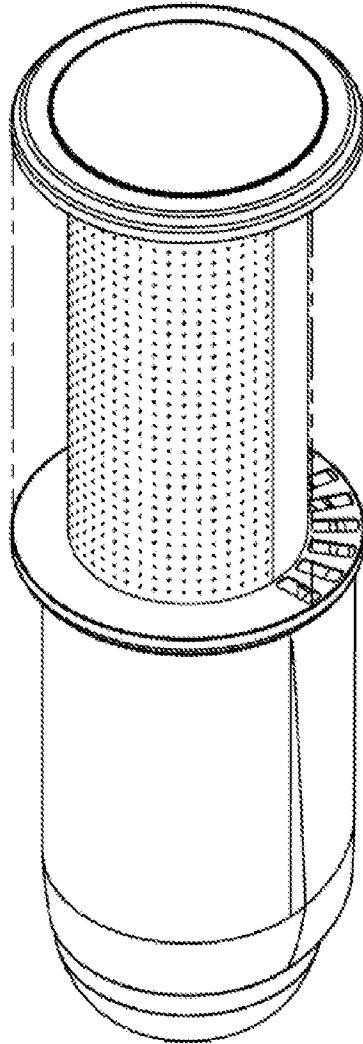


FIG. 5A

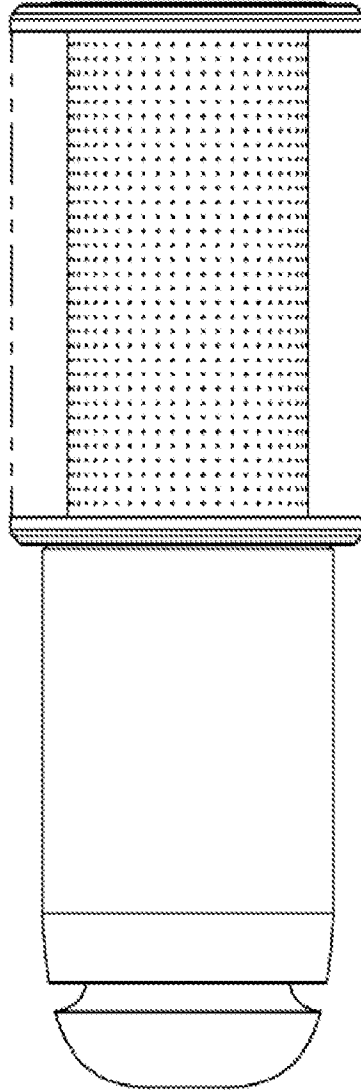


FIG. 5B

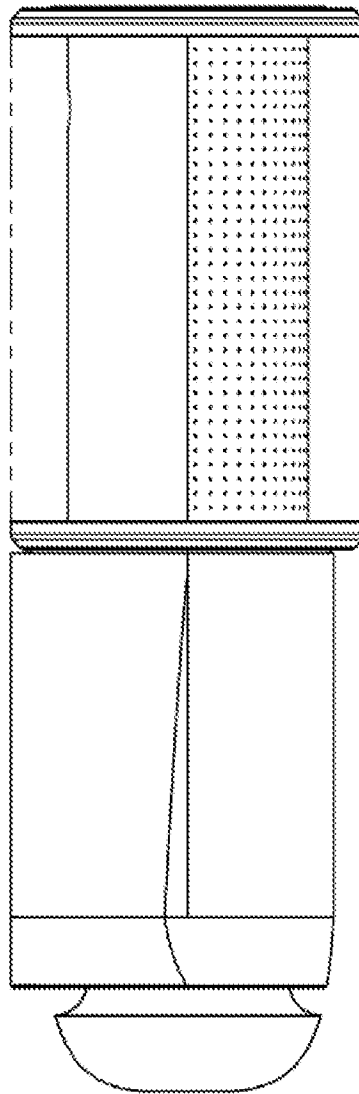


FIG. 5C

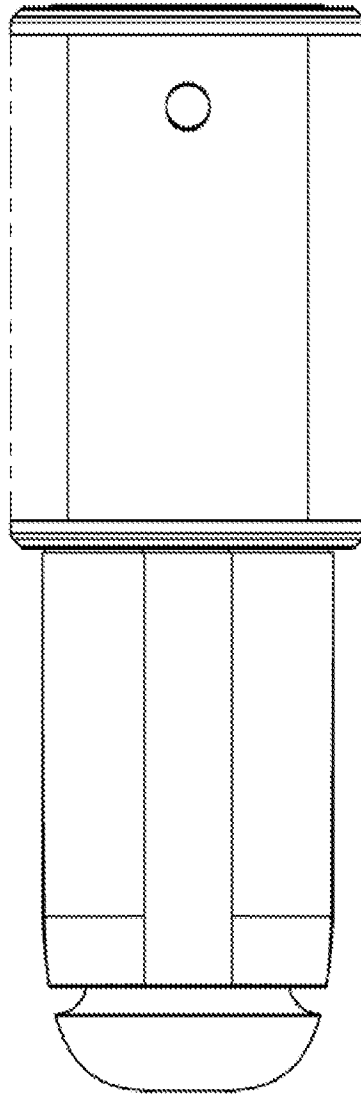


FIG. 5D

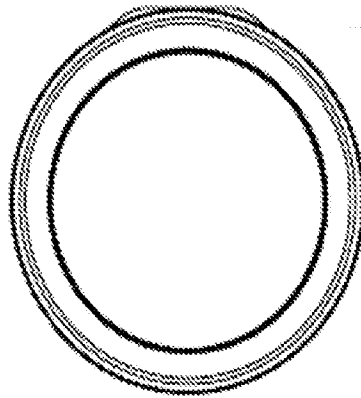


FIG. 5E

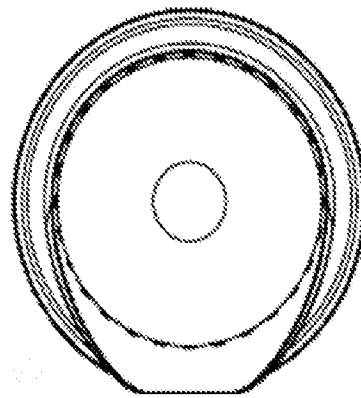


FIG. 5F

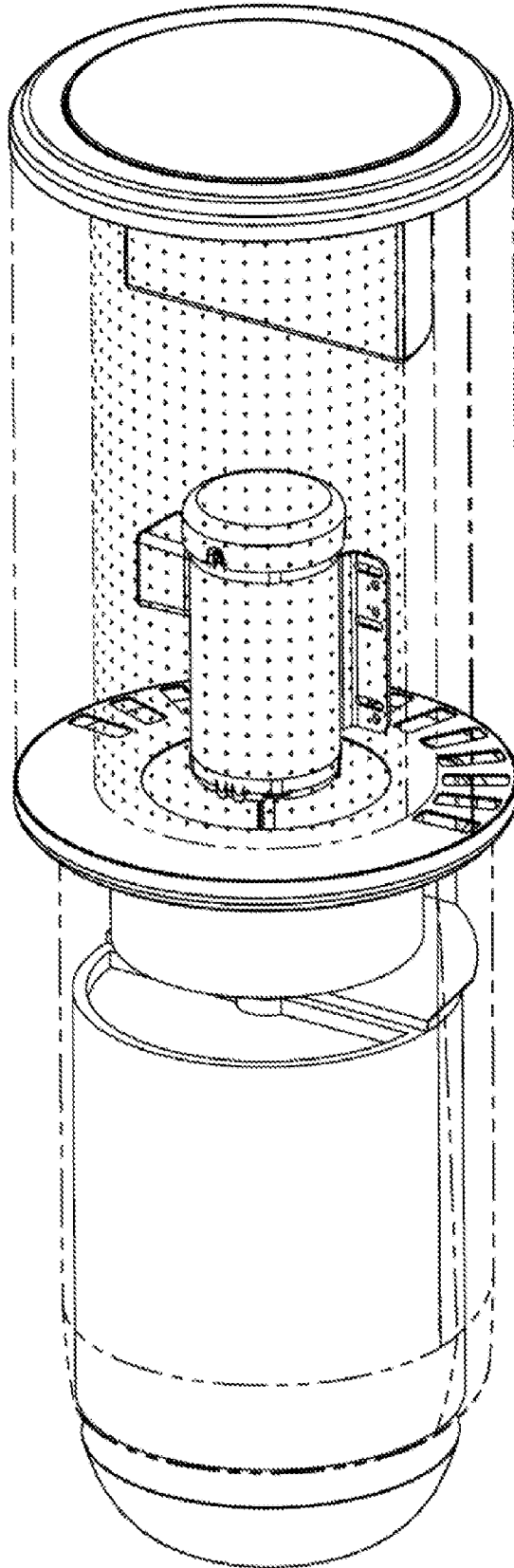


FIG. 5G

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/059347

A. CLASSIFICATION OF SUBJECT MATTER		
<i>D06F 58/10 (2006.01)</i> <i>D06F 58/28 (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)		
D06F 58/00-58/10, 58/26, 58/28, F26B 21/00		
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)		
PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 291149 A (MATTHEWS & YATES LIMITED et al.) 24.05.1928, p.1, lines 30-40, p.2, lines 20-70, fig.1-3	1, 2, 5, 9-11, 15-17, 23-25
Y		3-4,6-8,12-14,18-22, 26
A		27-32
Y	GB 1491852 A (THORN DOMESTIC APPLIANCES LTD) 16.11.1977, col.1, lines 10-35, fig.2	3-4
Y	EP 2423375 A1 (ELECTROLUX HOME PRODUCTS CORPORATION N.V.) 29.02.2012, paragraphs [0004], [0064]-[0065]	12-14, 18-20
Y	US 2018/0010289 A1 (KONINKLIJKE PHILIPS N.V.) 11.01.2018, paragraphs [0001], [0004], [0031]-[0044]	21, 22, 26
Y	US 3352076 A (WHEELING STEEL CORPORATION) 14.11.1967, col.2, lines 10-60	6-8
<input type="checkbox"/> Further documents are listed in the continuation of Box C.		<input type="checkbox"/> See patent family annex.
* Special categories of cited documents:	“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	
“A” document defining the general state of the art which is not considered to be of particular relevance	“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	
“E” earlier document but published on or after the international filing date	“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	
“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)	“&” document member of the same patent family	
“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		
Date of the actual completion of the international search	Date of mailing of the international search report	
26 March 2019 (26.03.2019)	11 April 2019 (11.04.2019)	
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer S. Shmakova Telephone No. 8(495) 531-64-81	