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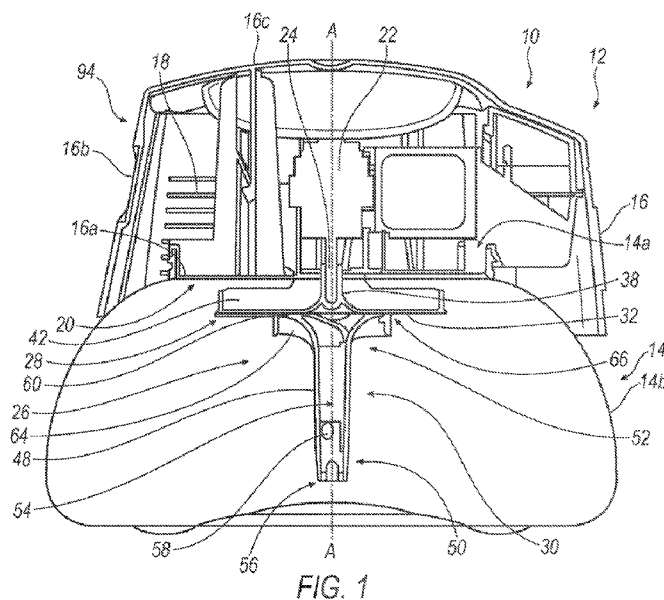
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(54) Title: CENTRIFUGAL PUMP AND FAN ASSEMBLY



(57) Abstract: A pump-fan assembly of an air modification device may include a fan, a pump and a disk. The fan may include a central hub disposed on a top surface of the disk, and a plurality of blades extending from the hub towards an outer circumferential edge of the disk. The pump may include a hollow pump body defining an inner tubular passage between an inlet end and a discharge end. An impeller may be arranged at the inlet end and an outlet port may be arranged at the discharge end. The pump and the fan may be coupled at an interface between the discharge end of the pump body and a bottom surface of the disk. The outlet port may be disposed in the interface and arranged to guide a stream of pumped liquid along the bottom surface of the disk. The disk may define a liquid barrier.

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CENTRIFUGAL PUMP AND FAN ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Patent Application No. 15/169,161,
5 entitled Centrifugal Pump and Fan Assembly, which was filed on May 31, 2016, and which is
hereby incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates generally to an apparatus for air freshening and/or
deodorizing, misting, and the like, and in particular to a centrifugal pump and fan assembly.

10

BACKGROUND

[0003] Various devices and apparatuses have been developed that "freshen" air by
delivering a volatizable material such as a fragrance, fragrant, perfume or disinfectant to an
environment of use. Such devices, commonly referred to as air fresheners, discharge volatized
materials such as fresheners, deodorizers or aromatic vapors into the air to modify the
15 atmosphere of the surrounding environment. Some air freshener devices deliver volatizable
material passively or without the need for additional energy input. For example, a passive air
freshener may have a reservoir which contains a volatizable material that is released into the
environment as the volatizable material evaporates (e.g., ambient evaporation).

[0004] In addition to passive devices, active air freshener devices have been developed to
20 aid in the dissemination of the volatizable material. For example, an active air freshener device
may have a fan to circulate the volatizable material more rapidly and/or in higher concentration.
The fan may be coupled to a power source, such as an electrical motor, to draw in air to enhance
the dissemination of the volatizable material from a source such as a reservoir. In this case, a
wick or some other type of mechanism is inserted into the reservoir containing the liquid
25 fragrant, where the wick then communicates the volatizable material through its length
whereupon the airflow assisted by the fan disseminates the volatizable material.

[0005] One type of fan-based air freshener device incorporates a centrifugal fan to assist
in circulating the volatizable material such as fragrance laden air and a water reservoir or basin

that may contain a fragrance to disperse an aesthetic scent into the environment. Centrifugal fans typically change the direction of airflow after the air enters into the system and expels the air in a radial direction. However, such fan-based devices suffer from various obstacles due at least in part to the centrifugal airflow as well as holes or apertures in the fan that allow the liquid to seep
5 into the exhausted airflow. In particular, air is drawn into the housing and expelled through outlets or vents that are disposed radially from the entry point and/or rotating fan. This forced airflow may induce liquid carry over to the air stream which may cause the device to "weep" or "spit" small drops of liquid out the air vents during operation. Weeping occurs when liquid droplets form within the device near the vents and the rush of forced airflow exhausted therefrom
10 lifts the liquid droplets out of device where they subsequently fall out onto the exterior housing giving an appearance that the housing is weeping. Spitting occurs in a similar manner as weeping and may be described as liquid droplets falling or accumulating on the floor or an area local to the device giving an appearance that the device is spitting out liquid. This "weeping" and/or "spitting" effect may cause damage or even failure to the device, as well as unsightly drawbacks
15 that require cleaning.

[0006] Another problem associated with centrifugal fan devices, due at least in part to manufacturing variation in run-out, liquid reservoir over-filling, and/or evaporation or clogging during prolonged use, is the inability to draw a consistent amount of volatizable material such as fragrance containing liquid from the liquid reservoir to disperse the fragrance laden air into the
20 environment.

[0007] Accordingly, it has become increasingly desirable to improve the overall design and operation of air freshener devices.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] While the claims are not limited to a specific illustration, an appreciation of the various aspects is best gained through a discussion of various examples thereof. Although the
25 drawings represent illustrations, the drawings are not necessarily to scale and certain features may be exaggerated to better illustrate and explain an innovative aspect of an example. Further, the exemplary illustrations described herein are not intended to be exhaustive or otherwise limiting or restricted to the precise form and configuration shown in the drawings and disclosed
30 in the following detailed description. Exemplary embodiments are described in detail by

referring to the drawings as follows:

[0009] **FIG. 1** illustrates a cross-sectional side view of an air modification device;

[0010] **FIG. 2** illustrates a side view of a pump-fan assembly of the air modification device;

5 [0011] **FIG. 3** illustrates an elevated perspective view of a fan for the pump-fan assembly;

[0012] **FIG. 4** illustrates a cross-sectional side view of a pump for the pump-fan assembly;

10 [0013] **FIG. 5** illustrates a top view of the pump of **FIG. 4**, according to an implementation;

[0014] **FIG. 6** illustrates a bottom perspective view of the pump-fan assembly mounted to a head assembly of the air modification device of **FIG. 1**; and

[0015] **FIG. 7** illustrates a cross-sectional side view of the air modification device of **FIG. 1**, showing various air and liquid flow paths during operation.

15 DETAILED DESCRIPTION

[0016] Referring now to the drawings, exemplary illustrates are shown in detail. The various features of the exemplary approaches illustrated and described with reference to any one of the figures may be combined with features illustrated in one or more other figures, as it will be understood that alternative illustrations that may not be explicitly illustrated or described may be able to be produced. The combinations of features illustrated provide representative approaches for typical applications. However, various combinations and modifications of the features consistent with the teachings of the present disclosure may be desired for particular applications or implementations. The representative illustrations below relate generally to a pump-fan assembly of an air modification device such as an apparatus for air freshening, deodorizing, 20 disinfecting and/or misting. Artisans may recognize similar applications or implementations with other technologies and configurations.

[0017] An exemplary pump-fan assembly includes a fan sub-assembly including a disk and a hub disposed on a top or air surface for coupling the fan sub-assembly to a rotating shaft, and a pump sub-assembly coupled to a bottom or liquid surface of the fan sub-assembly in a rotationally secure manner. The pump sub-assembly includes a hollow body extending axially 30

downward into a water basin. The hollow body has a suction end that can be submerged in liquid contained in the basin and a discharge end having one or more outlet ports for dispersing pumped liquid on the bottom side of the disk. Pursuant to certain implementations, the bottom or liquid surface of the fan sub-assembly is sealed throughout a radial extent of the disk to separate a flow of pumped liquid from the top or air surface of the disk. For example, the disk may be configured as a liquid impermeable or impassible barrier to minimize liquid flow, that is, without any holes or apertures that traverse the axial extent or thickness of the disk.

[0018] Accordingly, unlike conventional active freshener devices that have at least one aperture or passage in a spinning disk in order to facilitate dispersion of a liquid or a volatilized material into the circulating air stream, the pump-fan assembly of the disclosure acts to separate the two moving fluids via a fan disk implemented to minimize or act as a barrier against liquid flow. In one exemplary approach, a liquid impenetrable or impermeable fan disk prevents a significant amount of water from escaping through the air path. Thus, the pump-fan assembly eliminates or at least mitigates the problems associated with weeping and/or spitting.

[0019] The pump-fan assembly according to the disclosure is implemented with an intention of producing a consistent amount of liquid, which may be infused with a volatilizable material such as a fragrant, to the top of the basin while avoiding the pumped liquid from leaking into the blow air. As the pump-fan assembly is rotated about an axis, the top side of the fan draws in air axially and propels the air radially towards the side of the device housing. At the same time, liquid is propelled up in an axial direction through the pump via an inner tubular passage to the top of the pump, where the liquid is released through outlets and onto a bottom surface of the fan. According to one implementation, the bottom surface of the fan is smooth and non-textured, which allows the pumped liquid to "stick" to the bottom surface of the fan via surface tension. Once the liquid is on the bottom surface of the fan, the liquid flows in streams accelerating radially until the liquid reaches an outer circumferential edge of the fan where the liquid is then flung outwardly spattering onto the inside surface of the basin and falls to the bottom which gives an appearance of a "rain effect" inside of the basin.

[0020] By way of the fan disk, the active flow path air and the active flow path of liquid are separated from one another, which reduces or prevents significant amounts of liquid carry over into the air flow path. However, the volatilizable material contained in the liquid disperses into the air flow due to a unique flow pattern created by the pump-fan assembly. More

specifically, the first active flow path of air interacts with the second active flow path of liquid in a zone disposed radially between the side of the device housing and/or basin and the fan, referred to as a "shear zone." As the air is forced radially outwardly along the top surface of the fan disk and the liquid is accelerated along the bottom surface of the fan disk, the air path and the liquid path flow in adjacent layers or collaterally like two sheets of paper resting against one another, similar to a laminar flow. The air path and the liquid path touch, but do not mix with each other to any significant degree, wherein a certain amount of volatizable material is transferred to the air path and released into the surrounding environment via air vents. The majority of the liquid and volatizable material return to the basin for re-use, which has advantages with respect to reduced consumption of the comparatively expensive volatizable material (e.g., fragrant) as well as extended operating duration between servicing, e.g., until the liquid needs to be replenished.

[0021] References made herein to "fragrance," "fragrant," "freshener," "freshening," or other such terms related to exemplary forms of volatizable material should not be interpreted as being limited to deodorizing or pleasing aromas. For example, in some aspects the "fragrance" may be an insect repellant, a disinfectant or antiseptic, an allergen control ingredient or a medicinal substance, while the "freshener" may represent misting of vapors or a form of air circulation without the dispersion of chemicals to mask unpleasant odors. Further, references made herein to "liquid" are intended to encompass unblended liquid, such as water, volatile liquid, such as an oil fragrant, and a mixture or solution of a liquid containing a volatile chemical substance, such as water and fragrant.

[0022] Referring now to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views an air modification device is generally shown at **10**. As shown in **FIG. 1**, the air modification device **10** includes a head assembly **12** and a reservoir housing or basin **14** (hereinafter referred to as "basin") for holding a volume of liquid, such as water, and optionally a material such as a fragrant to be volatized, wherein the basin **14** has an opening **14A** and is coupled to the head assembly **12** in an assembled state. The basin **14** has a wall or walls **14B** that may be composed of a transparent material so as to clearly see the "rain effect" on the inner walls of the basin **14** during operation. The head assembly **12** may include a housing **16** defining an interior and one or more air openings **18** disposed in the housing **16** to facilitate the inflow and outflow of air into the head assembly **12** and one or more air vents **20** for air to enter and exit the basin **14**. The head assembly **12** includes a motor **22**

disposed within the housing **12**, wherein the motor **22** includes an output or drive shaft **24** for rotating about an axis **A-A**. The drive shaft **24** may extend through a bottom wall **16A** of the housing **16** and into an upper portion of the basin **14** via the opening **14A**. According to the illustrated example, the housing **16** provides a cover for the basin **14** via the bottom wall **16A** and a cap **94** for the motor **22** via a side wall **16B** and/or a top wall **16C**. The air openings **18** extend circumferentially along the radial side wall(s) **16B** of the housing **16** and may comprise louvered openings, although it is contemplated that air openings **18** may be disposed on the axial top wall **16C** of the housing **16** or a combination thereof. The air vents **20** are in fluid communication with the basin **14** to facilitate a flow of fluid. According to one implementation, the air vents **20** extend in a circumferential direction around bottom wall **16A** the housing **16** and at least partially surround the motor **22** mounted thereon. According to another implementation, the air vents **20** may be configured as an insertable part coupled to the side wall **16B** and/or the bottom wall **16A**. The bottom wall **16A** of the housing **16** may be configured to receive a light for illuminating the basin **14**. The head assembly **12** may include one or more switches (not shown) for activating the motor **22** and optionally the light separately or together, and an electrical connection for powering the device **10** if the motor **22** is electrically powered. A pump-fan assembly **26** is arranged at least partially in the basin **14** and drivingly connected to the motor **22** via the drive shaft **24**. The pump-fan assembly **26** includes a fan or fan assembly or fan sub-assembly **28** (hereinafter referred to as "fan") for inducing an airflow and a pump or pump assembly or pump sub-assembly **30** (hereinafter referred to as "pump") for drawing in a flow of liquid from the bottom of the basin **14** towards the fan **28**. The fan **28** and the pump **30** are arranged coaxially with the rotation axis **A-A**.

[0023] The pump-fan assembly **26** has a rotating disk **32** disposed in a region of the opening **14A** of the basin **14** and configured to impede the flow of pumped liquid from entering the airflow. As shown in the example of **FIG. 1**, the disk **32** is disposed axially below the air vents **20** to facilitate a separation of the airflow and the flow of liquid, although alternate arrangements are contemplated. In the following description, the disk **32** can be used interchangeably as a component of the fan **28** or of the pump **30**, and should not be interpreted as limited to a fan disk. As described in greater detail below, the pump-fan assembly **26** delivers a consistent amount of liquid to the top of the basin **14** while preventing the pumped liquid from leaking into the blown air, thereby minimizing or eliminating the "weeping" and "spitting" effect.

[0024] Referring to FIGS. 1, 2 and 3, the fan 28 comprises a centrifugal fan that draws in air axially and propels the air out radially. The fan 28 includes a disk 32 having a first, top, air surface 34 and a second, bottom, liquid surface 36. The terms "top" and "bottom" are in relation to the motor 22 and may respectively be identified as an axially upper surface and an axially lower surface in relation to the rotating axis A-A. A central hub 38 is disposed on the top surface 34 of the disk 32 and has a cavity 40 which is press fit onto the drive shaft 24 to connect the pump-fan assembly 26 to the motor 22. Additionally or alternatively, the mating portions of the cavity 40 and the drive shaft 24 may be splined or have a complementary key and keyway to define a spline joint or keyed joint, respectively, to facilitate a secure connection between the rotating drive shaft 24 and disk 32. A plurality of blades 42 are disposed on the top surface 34 and extend from the hub 38 towards an outer periphery or circumferential edge 44 of the disk 32. The plurality of blades 42 may be forward-curved blades, which are curved in a rotating direction R of the fan 28 as they extend from a fixed end adjacent or proximal to an axis of rotation associated with hub 38 radially outwardly to a free end adjacent or proximal to the circumferential edge 44, backward-curved blades, which are curved against the rotating direction R, or straight radial blades. A first connection mechanism 46 is disposed on the bottom surface 36 of the disk 32 for connecting the fan 28 to the pump 30. The first connection mechanism 46 may comprise a plurality of connecting elements including, but not limited to, clips, clasps, hooks, catches or the like.

[0025] According to one implementation, the fan 28 may be configured as a one-piece, monolithic and unitary part comprising the disk 32, the hub 38, the blades 42 and the connection mechanism 46. For example, the fan 28 may be formed as a single-unit injection molded part. According to another implementation, the disk 32, the hub 38, the blades 42 and the connection mechanism 46 may each be separate, and when combined together form the fan 28. For example, the hub 38 can be coupled to the disk 32 in a cup-like recess (not shown) via a mechanical and/or material connection. According to another implementation, the hub 38 and the blades 42 may be integrally formed as a single-unit (e.g., an injection molded part) that is coupled to the disk 32. The fan 28 may be composed of a material including plastic, such as polypropylene or some other polymer-based plastic, metal, ceramic, glass, or a combination thereof. As just one non-limiting example, the disk 32 may be formed of plastic and the hub 38 and/or blades 42 may be metal.

[0026] According to certain aspects of the disclosure, the fan **28** may define a rigid, impermeable or impenetrable membrane or barrier between the air and the liquid that prevents or at least minimizes the liquid from leaking into the blown air. Pursuant to one implementation, the disk **32** and the hub **38** are formed without holes or apertures throughout its thickness so that the disk **32** extends continuously throughout a radial extent of the bottom surface **36** (e.g., the area defined by the outer circumferential edge **44**). That is, the material of the disk **32** and the hub **38** may be formed continuously (e.g., without holes or apertures) so that the pumped liquid cannot leak axially through the fan **28**, but rather the pumped liquid is guided along the bottom surface **36** of the disk **32** until the liquid reaches the outer circumferential edge **44** of disk **32** where it is flung off the disk **32**. According to another implementation, at least the bottom surface **36** may be sealed throughout a substantial portion or an entire portion of the radial extent of the disk **32** to minimize a liquid flow to the top surface **34**. For example, the bottom surface **36** may be formed of a liquid impermeable material such as a continuous sheet, coating or layer of plastic, glass and/or metal. By configuring the fan **28** as a liquid impermeable part, problems with respect to "weeping" and "spitting" are reduced or avoided altogether (at least in any considerable amount). Additionally or alternatively, the top surface **34** and/or the bottom surface **36** may be formed smooth and non-textured which, in the case of the bottom surface **36**, facilitates a degree of surface tension to help guide the flowing liquid towards the outer circumferential edge **44**.

[0027] Consequently, the fan **28** operates in multiple capacities including a centrifugal fan for circulating air, a guide surface for urging the flowing liquid radially outwardly, and an impermeable (liquid) barrier between the blown air and the pumped liquid.

[0028] Referring again to **FIGS. 1** and **2**, the pump **30** includes a hollow body **48** having an inlet or suction end **50** (hereinafter referred to as "inlet end") and a discharge end **52**, wherein the body **48** defines an inner tubular flow passage **54** extending axially from the inlet end **50** to the discharge end **52**. The pump **30** can be formed of a material similar to that of the fan **28**, or the pump **30** and the fan **28** may be formed of different materials. According to an implementation, the pump **30** is formed as a plastic (e.g., polypropylene) injection molded part, although alternative polymer-based plastic, metal and/or ceramic materials are contemplated. Additionally, the pump **30** may include the disk **32** coupled to the body **48**, wherein the fan **28** includes the hub **38** and the blades **42** extending from a fixed end adjacent an axis of rotation

associated with hub **38** radially outwardly to a free end adjacent the outer circumferential edge **44**. In this case, the connection mechanism **46** may be disposed on the hub **38** for connecting with the disk **32**.

[0029] The body **48** of the pump **30** is conical in shape (e.g., funnel-shaped) and
5 increases in diameter from the inlet end **50** towards the discharge end **52** such that the inner flow passage **54** has a greater diameter at the discharge end **52** than the inlet end **50**. An impeller **56** is disposed at the inlet end **50** for axially priming the pump **30**, and radial relief ports **58** may be disposed in the body **48** above or downstream the impeller **56** to expel excess priming fluid, wherein two relief ports **58** may be provided that are disposed mutually opposite one another.
10 The impeller **56** may be formed from the same material as the body **48** or from a different material, and may be integral with the body **48** or formed as a separate component coupled to the body **48**. A lower portion of the inlet end **50** surrounding the impeller **56** may be tapered to facilitate the flow of liquid on the outside of the body **48** to also move in an upward manner, thereby reducing the likelihood of outside air being sucked into the impeller **56**. The discharge
15 end **52** includes a second connection mechanism **60** that interacts with the first connection mechanism **46** disposed on the bottom surface **36** of the disk **32** for coupling the pump **30** to the fan **28**. Preferably, the second connection mechanism **60** interacts with the first connection mechanism **46** in such a manner to form a snapped and rotationally fixed connection, and without requiring any attachment or positioning holes formed in the disk **32** and hub **38** of the
20 fan **28** so as to avoid potential leakage of the liquid into the blown air.

[0030] The second connection mechanism **60** of the discharge end **52** may comprise a flange **62** flaring outwardly in a radial direction such that the flange **62** defines an outer diameter (or outer periphery) greater than the outer diameter of the inlet end **50** and the discharge end **52**. The flange **62** may be integral with the discharge end **52** and thereby define a continuous and
25 indistinguishable extension of the body **48**. Although the flange **62** is shown as circular, other non-circular shapes are also contemplated. In the example illustrated in **FIGS. 1** and **2**, a plurality of detent ribs **64** are arranged on an outer, external surface of the flange **62** that extend from an upper portion of the body **48** up to or past the outer diameter of the flange **62**. The detent ribs **64** are configured to engage the first connection mechanism **46** disposed on the bottom
30 surface **36** of the disk **32** to rotationally secure the pump **30** to the fan **28** via a snap-fit connection. The detent ribs **64** advantageously prevent or reduce warping of the body **48**, which

may cause an increase in pumped liquid run-out variation. Further, the detent ribs **64** may have a curvature similar to that of the fan blades **42** to facilitate a swirling flow of liquid contained in the basin **14** that helps draw liquid into the pump **30**. A counter-detent element **84** may be arranged on the flange **62** circumferentially spaced from one or more of the detent ribs **64** to provide a rotational catch on both circumferential sides of the first connection mechanism **46**. Thus, the first connection mechanism **46**, which may comprise one or more hooks or clasps, are rotationally secured via a snap-fit connection so that the pump **30** can be secured to the fan **28** without any holes or apertures in the disk **32**.

[0031] At the interface **66** between the discharge end **52** of the pump **30** and the bottom surface **36** of the disk **32**, at least one and preferably a plurality of outlet ports **68** are arranged to release the pumped liquid radially so that a plurality of liquid streams are guided along the bottom surface **36** of the disk **32** to the outer circumferential edge **44**, where the liquid is then flung out radially by the rotating disk **32** to spatter against an inner wall of the basin **14** and/or an interior of the housing **16**.

[0032] As shown in greater detail in **FIGS. 4, 5 and 6**, the impeller **56** may be disposed within an inner diameter of the inlet end **50** and have one or more impeller blades **70** and one or more inlet openings **72** to force a liquid flow into the body **48**, wherein the illustrated example shows two impeller blades **70** and two inlet openings **72** distributed about an impeller eye **74**. A bubble plug **76** is disposed in the immediate vicinity of the impeller eye **74** to counteract the submerging of a gas bubble(s) that may form in the inner flow passage **54** at the impeller eye **74**, and a capacitance pool **78** may be defined downstream the impeller eye **74** between the bubble plug **76** (or surrounding area) and the relief ports **58** to maintain a sufficient amount of priming liquid.

[0033] The body **48** may further include one or more troughs **80** extending in the inner flow passage **54** between the inlet end **50** and the discharge end **52**, wherein the illustrated example shows two mutually opposite troughs **80** spaced circumferentially from the relief ports **58**. The troughs **80** define a groove in the interior of the body **48** having a geometry, such as a parabolic angle geometry, configured such that the inner flow passage **54** has a greater inner diameter at the troughs **80**. Such a configuration of the body **48** via the troughs **80** delivers a small percentage of the fluid in the capacitance pool **78** to the outlet ports **68** above, the remainder of the fluid being exhausted through the relief ports **58**. Accordingly, the troughs **80**

induce rotational acceleration of the liquid so that a metered amount of liquid is more quickly pushed outwardly by centrifugal force and moves upward along the troughs **80** to the discharge end **52**. The troughs **80** may further be configured sloped radially outwards from the rotation axis **A-A** to centrifugally raise a metered and consistent amount of liquid to the discharge end **52**. As shown in the illustrated examples of **FIGS. 4** and **5**, one or a plurality of channels **82** may extend from an axially top or discharge side of the troughs **80** to the outlet ports **68** to guide the pumped liquid in a consistent manner, wherein the channels **82** may have a curvature similar to that of the fan blades **42** to facilitate a smooth transition of the liquid flow from an axial direction to a radial direction. The size of the outlet ports **68** and the channels **82** controls the size of the water droplets flung out radially from the bottom surface **36** of the disk **32**, which influences the extent of the "rain effect" or the spattering of the water droplets against and/or running down the interior of the basin **14**.

[0034] Referring in particular to **FIG. 5**, the flange **62** has an inner surface in fluid communication with the flow passage **54** and includes the outlet ports **68** distributed circumferentially about the outer periphery, wherein the channels **82** can be seen extending from the pair of troughs **80** to a corresponding pair of outlet ports **68**. The flange **62** in the illustrated example has a tulip-like or trumpeted shape, which serves for improving the flow characteristics of the discharged liquid as the liquid moves from the inner flow passage **54** to the outlet ports **68**. The flange **62** may further include mounting surfaces **86** that engage and rest substantially flush with the bottom surface **36** of the fan disk **32**. The mounting surfaces **86** may include a greater thickness than the remaining portions of the flange **62** to enhance the snap-fit connection between the pump **30** and the fan **28**, which may be snapped into place via a twisting motion. If the flange **62** includes mounting surfaces **86**, the outlet ports **68** are distributed circumferentially between adjacent mounting surfaces **86**.

[0035] The assembled pump-fan assembly **26** is shown in greater detail in **FIG. 6**, wherein the discharge end **52** of the pump **30** via the flange **62** is coupled to the bottom surface **36** of the fan disk **32**. The detent ribs **64** and the counter-detent elements **84** of the flange **62** rest on both circumferential sides of the first connection mechanism **46** of the disk **32**, wherein the first connection mechanism **46** has an axial hook or overlap engaging the flange **62**, to rotationally, axially and radially secure the pump **30** and the fan **28** to one another. The pump-fan assembly **26** is then coupled to the motor **22** via a press-fit connection between the fan hub **38**

and the drive shaft **24**, and the head assembly **12** is mounted on the basin **14** to the assembled state as shown in **FIG. 1**.

[0036] Referring to **FIG. 7**, the pump-fan assembly **26** produces a unique flow pattern of a liquid flow that is separate from an air flow in the following manner. When the pump-fan assembly **26** is rotated by the motor **22**, a first active flow **88** and a second active flow **90** are generated. The first active flow **88** of air enters the cap **94** of the head assembly **12** through the air openings **18** and flows axially into the center of the fan **28** on the top side or side opposite the pump **30**. The blades **42** increase the velocity of the air as it moves across the top surface **34** and propels the air radially outwardly into the shear zone **92** between the fan **28** and the interior of the wall(s) **16A**, **16B**, **16C** of the housing **16** and/or the interior of the wall **14B** of the basin **14**, where the air is then exhaust through the vents **20** at least partially surrounding the opening **14A** of the basin **14** and out of the cap **94** of the head assembly **12** via the openings **18**. In the second active flow **90**, liquid from the basin **14** is forced into the body **48** of the pump **30** by the impeller **56** and the liquid flows up the body **48** via the inner flow passage **54**, which axially upward flow is facilitated by the troughs **80** and the increasing diameter of the inner flow passage **54**. The pump **30** delivers a metered and intended consistent flow of liquid to the discharge end **52** at least in part due to the troughs **80** and by drawing in a higher volume at the inlet end **50** and expelling excess liquid through the relief ports **58**. Once at the discharge end **52**, the liquid flow (e.g., liquid droplets) is guided to the bottom surface **36** of the disk **32** via the channels **82** and outlet ports **68**, and then moves across the bottom surface **36** of the disk **32** until the liquid reaches the outer circumferential edge **44**. Surface tension facilitated by a smooth, non-textured bottom surface **36** aids in the guiding of the liquid radially across the disk **32**. The liquid is then flung out radially through the shear zone **92** and spatters against an interior of the wall **14B** of the basin **14** and/or an interior of the wall(s) **16A**, **16B**, **16C** of the housing **16** where the liquid returns to the pool at the bottom of the basin **14** via a "rain effect" of liquid falling along the wall **14B** of the basin **14**.

[0037] The disk **32**, which also functions as a liquid barrier as discussed above, accelerates the first active flow **88** of air along the top surface **34** and the second active flow **90** of liquid along the bottom surface **36** so that the air path and the liquid path flow into the shear zone **92** collaterally or in substantially adjacent and parallel layers. The air flow and the liquid flow touch one another in the shear zone **92**, but do not mix with each other in any significant

amount. The pump-fan assembly **26**, therefore, has significant improvements with respect to liquid carry over from the second active path **90** of liquid into the first active flow **88** of air that gives rise to the "weeping" and "spitting" effect. In the shear zone **92**, fragrance and water vapor are transferred from the second active flow **90** of liquid to the first active flow **88** of air, which
5 then exits into the environment via the vents **20** and openings **18** to freshen, deodorize, and/or mist the atmosphere. The majority or substantial portion of the liquid and fragrant return back to the basin **14** via the "rain effect," which provides savings with respect to liquid and fragrant consumption as well as an aesthetically pleasing look.

[0038] It will be appreciated that the aforementioned devices and systems may be
10 modified to have some components removed, or may have additional components added, all of which are deemed to be within the spirit of the present disclosure. Even though the present disclosure has been described in detail with reference to specific examples, it will be appreciated that a plurality of variants and changes can be made to these examples without departing from the scope of the present disclosure as set forth in the claims. It is anticipated and intended that
15 future developments will occur in the technologies discussed herein, and that the disclosed systems and devices will be incorporated into such future embodiments.

[0039] All terms used in the claims are intended to be given their broadest reasonable constructions and their ordinary meanings as understood by those knowledgeable in the technologies described herein unless an explicit indication to the contrary is made herein. In
20 particular, use of the singular articles such as "a," "the," "said," etc. should be read to recite one or more of the indicated elements unless a claim recites an explicit limitation to the contrary. Additionally, use of adjectives such as first, second, etc. should be read to be interchangeable unless a claim recites an explicit limitation to the contrary.

CLAIMS

I/We claim:

1. An assembly comprising:
 - a fan sub-assembly including:
 - a disk rotatable about an axis having an air surface and a liquid surface disposed axially opposite the air surface,
 - a central hub disposed on the air surface for receiving a drive member, and
 - a plurality of blades disposed on the air surface extending from the hub towards an outer peripheral edge of the disk; and
 - wherein the liquid surface is sealed throughout a radial extent of the disk to separate a flow of supplied liquid from the air surface of the disk.
2. The assembly of claim 1, wherein the liquid surface of the disk extends continuously along a radial direction within the outer circumferential edge to define a barrier to minimize liquid flow.
3. The assembly of claim 1, wherein the fan sub-assembly includes a first connecting mechanism disposed on the liquid surface of the disk for receiving a pump with a second connection mechanism interacting with the first connection mechanism.
4. The assembly of claim 3, further comprising a pump sub-assembly including:
 - a hollow pump body having an inlet end and a discharge end, the pump body defining an inner tubular passage extending from the inlet end to the discharge end, and
 - at least one outlet port disposed at the discharge end and arranged to guide the flow of liquid along the liquid surface of the disk, wherein the discharge end of the pump body includes the second connection mechanism.
5. The assembly of claim 4, further comprising at least one trough disposed in the inner tubular passage of the pump body and extending axially between the inlet end and the discharge end.

6. The assembly of claim 5, wherein the inner tubular passage includes at least one channel arranged in a region of the discharge end and extending from a discharge side of the at least one trough to the at least one outlet port.
7. The assembly of claim 4, wherein the pump sub-assembly further includes an impeller arranged at the inlet end, and wherein the pump body includes at least one radial relief opening disposed axially between the impeller and the discharge end.
8. The assembly of any of claims 4-7, wherein the discharge end includes a flange having an inner surface mounted to the liquid surface of the disk, and wherein the at least one outlet port is arranged on the inner surface of the flange.
9. The assembly of claim 8, further comprising a plurality of ribs distributed circumferentially on an outer surface of the pump body and extending along the flange towards the disk, wherein the plurality of ribs engage the first connection mechanism of the disk in a rotationally fixed manner.
10. The assembly of claim 4, wherein the disk is integral with one of the fan sub-assembly and the pump sub-assembly.

11. An air modification apparatus, comprising:
- a housing having at least one opening for air to traverse;
 - a motor disposed in the housing and having a drive shaft for rotating about an axis;
 - a basin coupled to the housing for containing a liquid; and
 - a pump-fan assembly coupled to the drive shaft and at least partially extending into the basin, wherein the pump-fan assembly includes:
 - a fan assembly including a central hub having a cavity receiving the drive shaft, and a plurality of blades extending outwardly from the hub;
 - a pump assembly including a hollow pump body extending into the basin, the pump body having an inlet end, an axially opposite discharge end, and an inner tubular passage extending from the inlet end to the discharge end, the pump assembly further including an impeller arranged at the inlet end, an outwardly flared flange extending from the discharge end, and a plurality of circumferentially distributed outlet ports disposed in an inner surface of the flange;
 - a disk arranged between the hub of the fan assembly and the pump body of the pump assembly, the disk having a top surface coupled to the hub of the fan assembly and an axially opposite bottom surface;
 - wherein the pump assembly is rotationally fixed to the fan assembly via a mechanical connection between the flange of the discharge end and the bottom surface of the disk; and
 - wherein the disk defines a liquid barrier throughout a radial extent of the bottom surface.
12. The apparatus of claim 11, wherein in response to the drive shaft rotating about the axis, the fan assembly induces a centrifugal air flow propelled radially along the top surface of the disk and the pump produces a centrifugal liquid flow from the inlet end to the plurality of outlet ports so that the liquid flow is released along the bottom surface of the disk without passing axially through the disk to the top surface.

13. The apparatus of claim 11, wherein at least one of:
 - the pump body includes at least two mutually opposite troughs extending in the inner tubular passage between the inlet end and the discharge end; and
 - the pump body includes at least two mutually opposite relief ports disposed proximal to the inlet end.
14. The apparatus of claim 13, wherein the pump body further includes at least two channels extending from the at least two troughs to the plurality of outlet ports.
15. The apparatus of claim 11, wherein the disk is integral with one of the fan assembly and the pump assembly.
16. The apparatus of claim 11, wherein the inner surface of the flange has a plurality of mounting surfaces for engaging the bottom surface of the disk, and wherein the plurality of mounting surfaces are spaced circumferentially apart from one another.
17. The apparatus of claim 11, wherein the bottom surface of the disk is sealed continuously throughout the radial extent.
18. The apparatus of any of claims 11-17, wherein the pump assembly further includes a plurality of detent ribs distributed circumferentially from one another on an outer surface of the flange, and wherein the plurality of detent ribs interact with a connection mechanism disposed on the bottom surface of the disk to define the mechanical connection.

19. An air modification system, comprising:
- a housing having at least one opening for air to traverse;
 - a motor disposed in the housing and having a drive shaft for rotating about an axis;
 - a basin coupled to the housing for containing a liquid;
 - at least one air vent arranged to be in communication with the basin and the housing; and a pump-fan assembly coupled to the drive shaft and at least partially extending into the basin, wherein the pump-fan assembly includes:
 - a fan including a disk, a central hub arranged on a top surface of the disk and coupled to the drive shaft via a press-fit connection, and a plurality of blades extending from the central hub towards an outer circumferential edge of the disk for generating a centrifugal air flow along the top surface of the disk; and
 - a pump including a hollow pump body having an inlet end, a discharge end and an inner tubular passage extending in an axial direction between the inlet end and the discharge end, wherein the inlet end extends into the basin to deliver liquid via the inner passage to the discharge end, and the discharge end is coupled to a bottom surface of disk, and wherein at least one outlet port is disposed at an interface between the discharge end and the bottom surface of the disk;
 - wherein liquid droplets expelled from the pump via the at least one outlet port are guided along the bottom surface of the disk and dispersed in a radial direction outwardly towards the basin so that air traveling in the centrifugal air flow and said liquid droplets flow in a collateral path from the outer circumferential edge of the disk.
20. The system of claim 19, wherein the bottom surface of the disk extends sealed along the radial direction within the outer circumferential edge to define a liquid barrier to minimize liquid carry over to the top surface.

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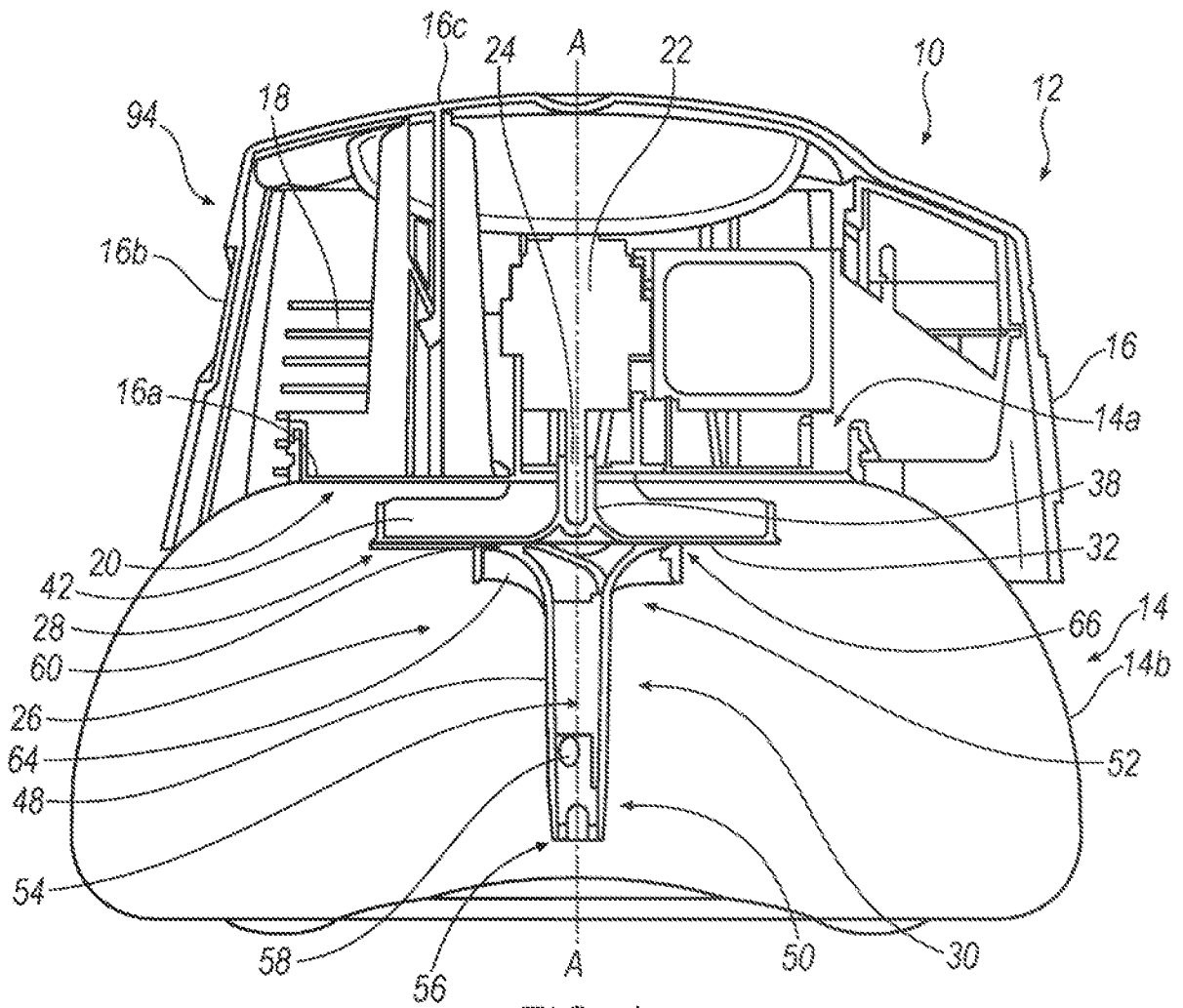


FIG. 1

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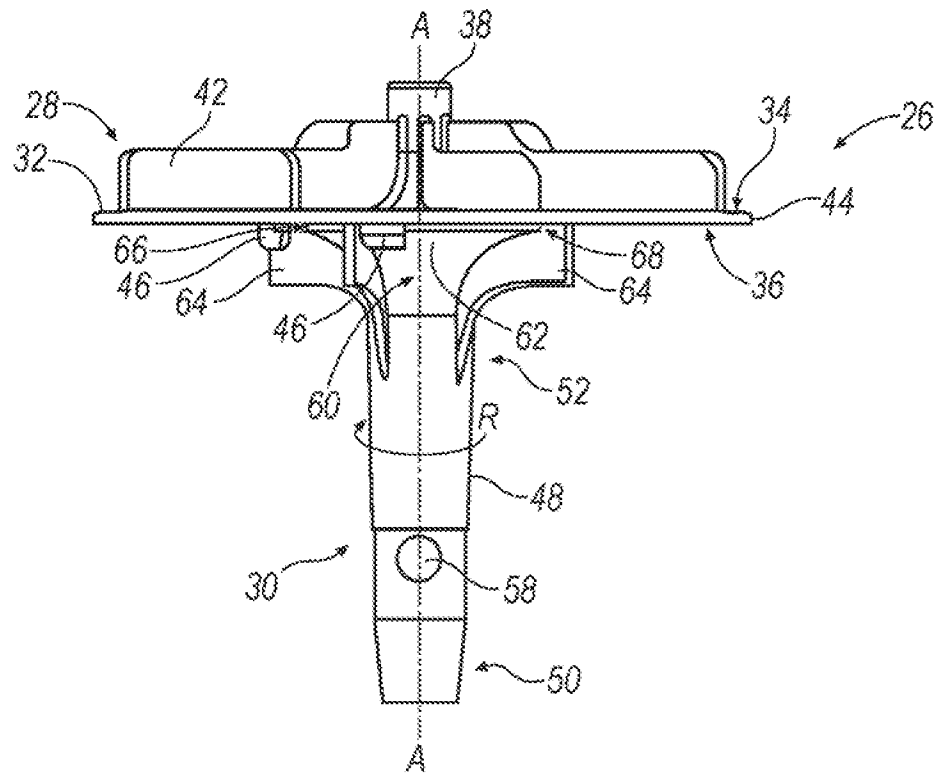


FIG. 2

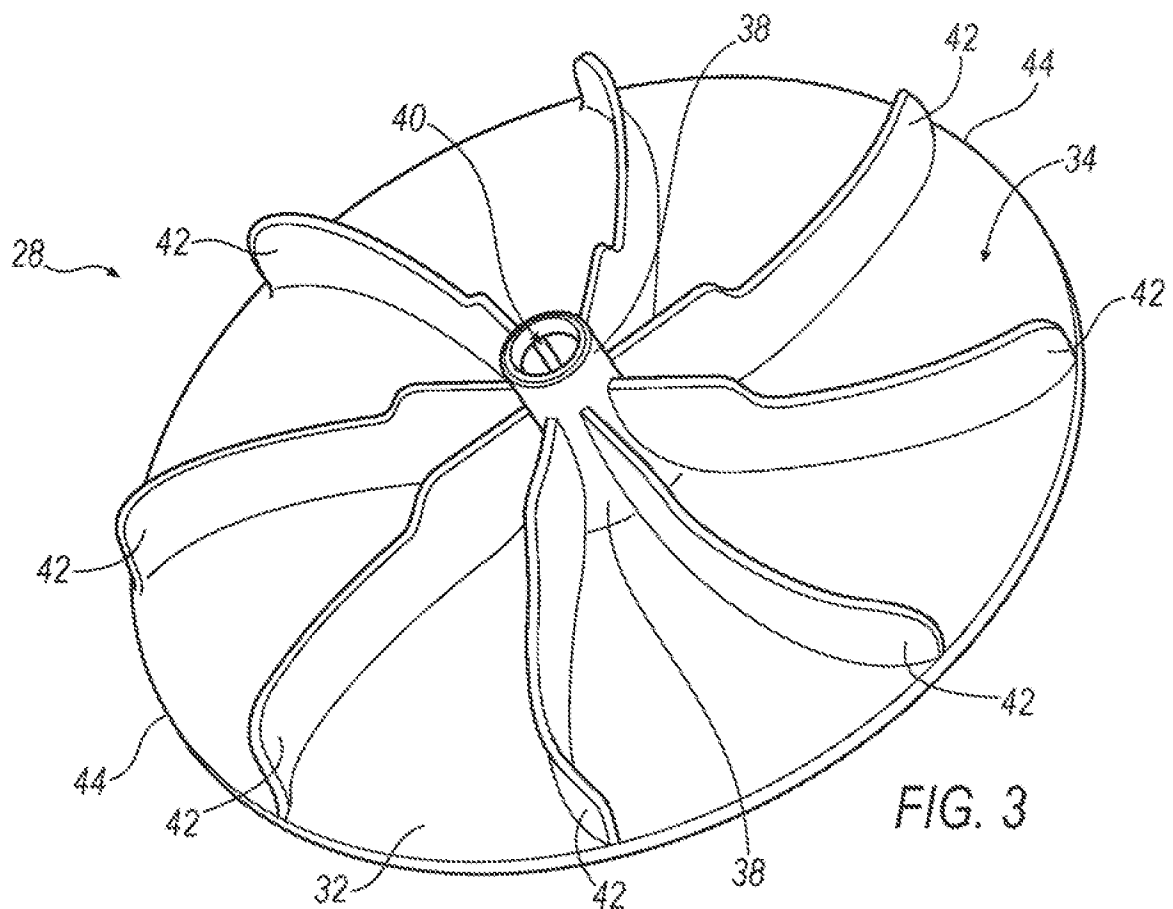


FIG. 3

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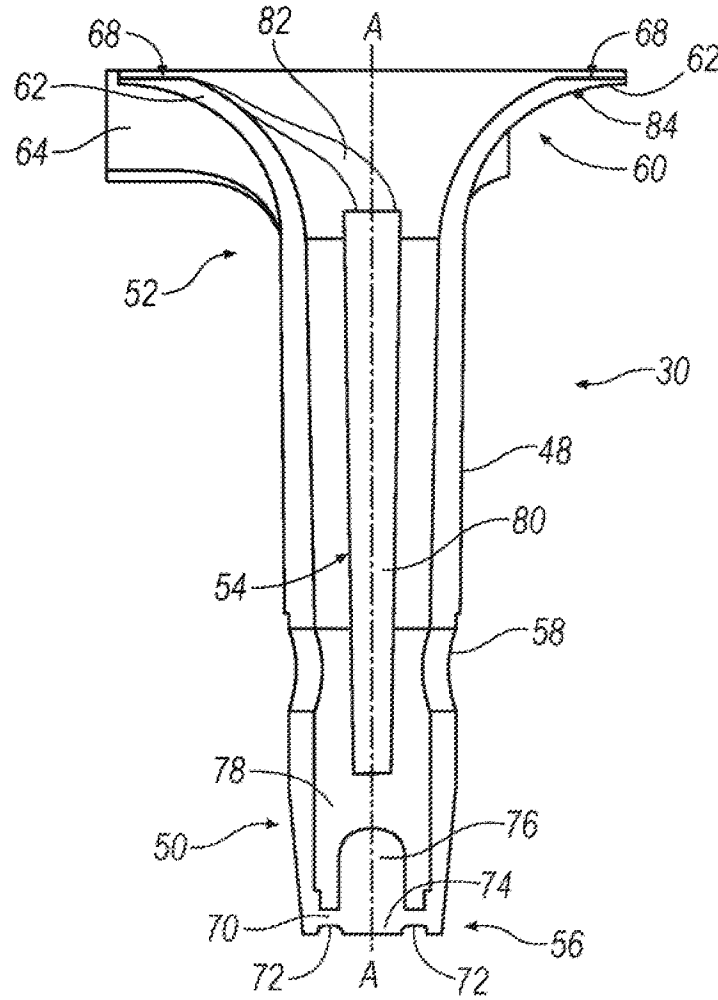


FIG. 4

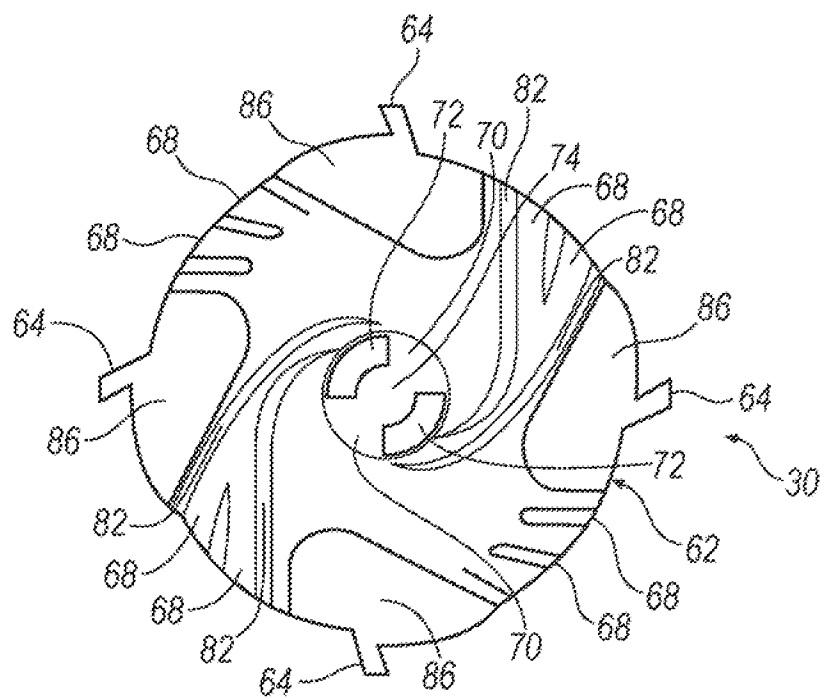
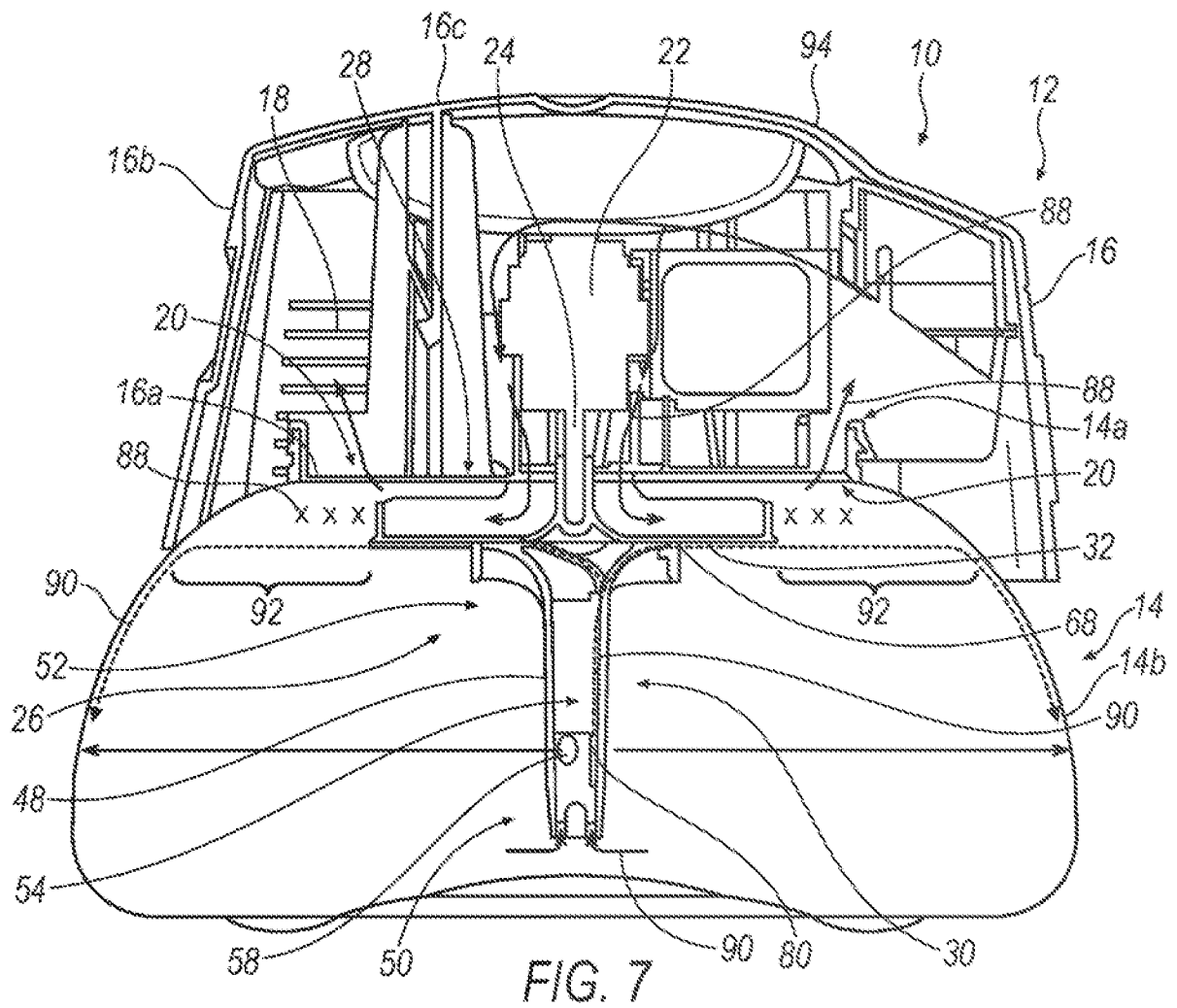
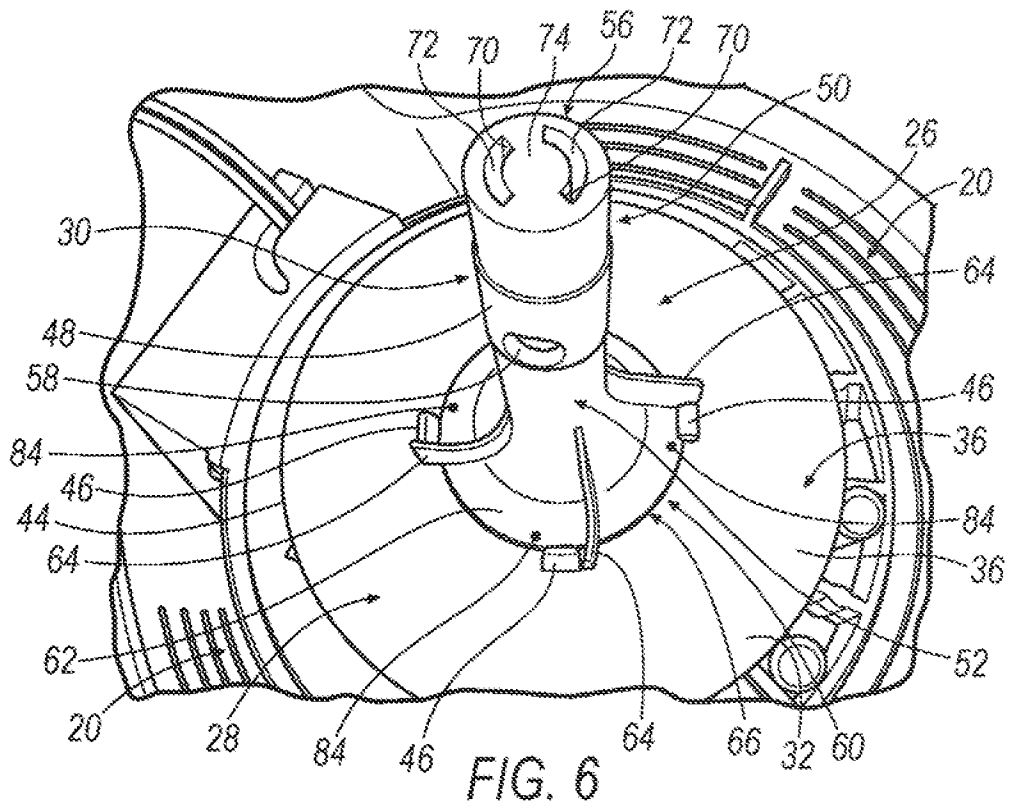


FIG. 5

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/034138

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61L9/12 F04D25/02 F24F5/00
ADD.

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)

A61L F04D F24F

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)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 840 770 A (WALZ DAVID K [US] ET AL) 20 June 1989 (1989-06-20)	1-10
A	abstract; figures column 4, lines 5-64	11-20
X	US 4 833 895 A (JOHNSON DWIGHT N [US]) 30 May 1989 (1989-05-30)	1-10
A	abstract; figures	11-20
X	EP 2 138 725 A2 (MOMENTUM IND LLC [US]) 30 December 2009 (2009-12-30)	1-10
X	WO 2013/188499 A2 (JOHNSON & SON INC S C [US]; SHARMA NITIN [US]) 19 December 2013 (2013-12-19)	1-10
	abstract; figures	
	-/--	



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

21 July 2017

Date of mailing of the international search report

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Varga, Viktoria

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/034138

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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