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(54) IN-DOOR CONDENSER FOR LAUNDRY APPLIANCE

(57) A front-load laundry appliance (20) including an in-door condensing system (86) with an air-to-air condenser that forms an air cooling loop (98) inside an in-door cavity (35). The air cooling loop (98) is a tube that extends in a flat spiral to form multiple loops that gradually increase in radius. The in-door condensing system (86) includes an in-door circulation fan (94) and a heat exchanger fan (96). The in-door circulation fan (94) is positioned in the in-door cavity (35) and is arranged to pull moist air from inside the laundry compartment (66) into the in-door cavity (35) where it condenses. The heat exchanger fan (96) is also positioned in the in-door cavity (35) and is arranged to pull cooling air from outside the laundry appliance (20) into the air cooling loop (98) . The air cooling loop (98) of the in-door condenser (88) may alternatively receive a cooling air flow from a chiller (130) located inside the laundry appliance (20).

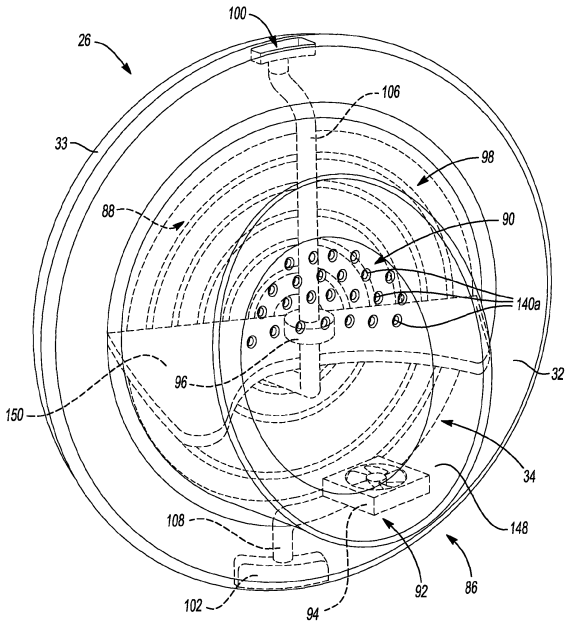

Fig-5

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Description

FIELD

[0001] The present disclosure relates generally to laundry appliances and more particularly to an in-door condenser for a front-load washer and dryer combination appliance.

BACKGROUND

[0002] The statements in this section merely provide background information related to the present disclosure and may not constitute as prior art.

[0003] Laundry appliances (i.e., laundry machines, washing machines, and dryers) are prolific in both residential and commercial settings. Traditionally, separate washer and dryer machines have been used in tandem to clean and dry laundry. However, there is a growing market for washer and dryer combination appliances where a single machine performs both the washing and drying functions, thereby eliminating the need for two separate machines. There are a number of different names used to describe washer and dryer combination appliances, including without limitation, "washer/dryer combos" and "all-in-one washer dryers." While these units save space compared to separate washer and dryer machines, combining the washing and drying functions into a single appliance presents a number of engineering challenges.

[0004] Many washer and dryer combination appliances have a front-load appliance configuration, where the washer and dryer combination appliance includes a cabinet with a front opening that is accessed by a front-mounted appliance door. A drum is positioned in and is rotatable with respect to the cabinet. During tumbling, a motor housed within the cabinet rotates the drum. The drum typically has a front end with a drum opening that provides access to a laundry compartment inside the drum.

[0005] Washer and dryer combination appliances are gaining in popularity because they save space compared to a set of separate washer and dryer appliances and because they do not require the act of transferring laundry between separate appliances between the wash and drying cycles. This allows consumers to simply load laundry into the washer and dryer combination appliance and select the desired wash and drying cycle settings and they do not have to return again until the laundry is washed and dried. However, performing the drying cycle in the same appliance that performed the wash cycle presents a number of engineering challenges due to the presence of water inside the drum during the wash cycle and the resulting levels of humidity that remain inside the appliance during the drying cycle. Solutions that improve the performance and efficiency of the drying cycle in washer and dryer combination appliances in the face of these challenges are needed.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] In accordance with one aspect of the present disclosure, a laundry appliance is provided that comprises: a cabinet with a front opening, a drum rotatably supported within the cabinet, a laundry compartment disposed inside the drum, and a front appliance door that is pivotally mounted with respect to the cabinet such that the front appliance door is configured to swing between a closed position where the front appliance door closes the front opening in the cabinet and an open position where the front appliance door is swung away from the front opening to provide access to the laundry compartment. The front appliance door has an outer wall, an inner wall, and a door perimeter. The inner wall of the front appliance door includes a bowl that defines an in-door cavity with the front appliance door. The bowl of the front appliance door is positioned such that at least a portion of the bowl extends into the front opening in the cabinet when the front appliance door is in the closed position. The laundry appliance further includes an in-door condensing system mounted within the in-door cavity. More specifically, the in-door condensing system has an in-door condenser, arranged as an air-to-air heat exchanger, that includes an air cooling loop positioned inside the in-door cavity.

[0008] In accordance with one aspect of the present disclosure, the air cooling loop of the in-door condenser is a tube that extends in a flat spiral to form multiple loops arranged in a condenser loop plane. The multiple loops of the tube forming the in-door condenser have a curvature that gradually increases in radius as the air cooling loop extends out towards the door perimeter.

[0009] In accordance with another aspect of the present disclosure, the in-door condensing system includes an in-door circulation fan, positioned in the in-door cavity, that is arranged to pull moist air from inside the laundry compartment into the in-door cavity, where the moist air flows past the air cooling loop of the in-door condenser to facilitate condensation in the in-door cavity. This removes moisture from the moist air that is pulled into the in-door cavity by the in-door circulation fan to create dryer air (i.e., air with less moisture) that is expelled out of the in-door cavity and back into the laundry compartment.

[0010] In accordance with another aspect of the present disclosure, the in-door condensing system includes a heat exchanger fan, also positioned in the in-door cavity, that is arranged to pull cooling air from outside the laundry appliance into the air cooling loop of the in-door condenser through an air intake located in the outer wall of the appliance door. In other words, in accordance with this aspect of the present disclosure, there are two fans positioned inside the in-door cavity - the in-door circulation fan that circulates moist air from the laun-

dry compartment through the in-door cavity and the heat exchanger fan that circulates cooling air from outside the laundry appliance through the air cooling loop of the in-door condenser.

[0011] In accordance with another aspect of the present disclosure, the air cooling loop of the in-door condenser is positioned inside the door cavity and is arranged to receive a cooling air flow from a chiller located inside the cabinet. In accordance with this aspect of the present disclosure, the chiller is arranged in fluid communication with the in-door condenser when the front appliance door is in the closed position and is configured to cool off the air in the cooling air flow at a location that is upstream of the in-door cooling loop.

[0012] In accordance with another aspect of the present disclosure, the laundry appliance includes a cabinet with a front opening, a drum that is rotatably supported within the cabinet, a front appliance door that opens and closes the front opening of the cabinet, and an in-door condensing system for removing moisture from laundry contained in the drum during a drying cycle. The drum has a laundry compartment that is accessible through the front opening in the cabinet and the front appliance door pivotally mounted with respect to the cabinet such that the front appliance door is configured to swing between a closed position where the front appliance door closes the front opening in the cabinet and an open position where the front appliance door is swung away from the front opening. The front appliance door includes a bowl that is positioned on the front appliance door such that at least a portion of the bowl extends into the front opening in the cabinet when the front appliance door is in the closed position. The bowl defines an in-door cavity within the front appliance door and the in-door condensing system is mounted within the in-door cavity.

[0013] The in-door condensing system includes an in-door condenser that is arranged as an air-to-air heat exchanger and includes an air cooling loop that is positioned inside the in-door cavity. An in-door circulation fan is also positioned in the in-door cavity and is arranged to pull moist air from inside the laundry compartment into the in-door cavity and past the air cooling loop of the in-door condenser to facilitate condensation in the in-door cavity and remove moisture from the laundry compartment.

[0014] In accordance with another aspect, the in-door condensing system includes an air inlet that is positioned in the bowl to define an air intake flow path along which moist air flows directly from the laundry compartment into the in-door cavity and an air outlet that is positioned in the bowl to define a return air flow path along which dry air from inside the in-door cavity flows directly into the laundry compartment.

[0015] In accordance with another aspect, the laundry appliance includes a partition that extends from the bowl towards the in-door condenser to divide at least part of the in-door cavity into first and second zones. In accordance with this aspect of the present disclosure, the air inlet and the air outlet may be positioned in different zones of the in-door cavity such that the partition directs airflow inside the in-door cavity past the in-door condenser before exiting through the air outlet. In accordance with another aspect of the present disclosure, the heat exchanger fan may be positioned in the same zone as the air outlet.

[0016] In accordance with another aspect, the laundry appliance further comprises a cooling air intake and a cooling air exhaust vent that are located in the front appliance door and are open to ambient air outside of the cabinet. In accordance with this aspect of the present disclosure, a cooling air intake duct and a cooling air exhaust duct are located in the front appliance door. The cooling air intake duct is arranged in fluid communication with and extends between the cooling air intake and the in-door condenser. The cooling air exhaust duct is arranged in fluid communication with and extends between the in-door condenser and the cooling air exhaust vent. The in-door circulation fan is arranged in fluid communication with at least one of the cooling air intake duct, the cooling air exhaust duct, and the in-door condenser for drawing ambient air in through the cooling air intake duct.

[0017] In accordance with another aspect, the laundry appliance further comprises a chiller that is located inside the cabinet and arranged to supply a cooling air flow to the air cooling loop. In accordance with this aspect of the present disclosure, the chiller may be an air-to-refrigerant heat exchanger and the cooling air flow that the chiller supplies to the air cooling loop of the in-door condenser may be expelled through a cooling air exhaust vent that is located in the front appliance door. In accordance with this aspect of the present disclosure, the laundry appliance may include an outside air inlet, located in the cabinet, that is open to ambient air outside of the cabinet and an outside air duct, located in the cabinet, that is arranged in fluid communication with and extends between the outside air inlet and an inlet side of the chiller. A compressor, located in the cabinet, is connected to the chiller by refrigerant lines that circulate refrigerant between the compressor and the chiller. The laundry appliance may also include a cool air duct, located in the cabinet, that is arranged in fluid communication with an outlet side of the chiller and a heat exchanger fan, located in said cabinet, that is arranged in fluid communication with at least one of the outside air duct, the cool air duct, and the chiller for drawing ambient air in through the outside air duct. In accordance with this aspect of the present disclosure, the laundry appliance may also include a cooling air intake, located in the front appliance door, that is arranged in fluid communication with the cool air duct in the cabinet when the front appliance door is in the closed position. In accordance with this aspect of the present disclosure, the laundry appliance may further include a cooling air intake duct and a cooling air exhaust duct that are located in the front appliance door. The cooling air intake duct is arranged in fluid communication with and extends between the cooling air intake and the in-door condenser.

The cooling air exhaust duct is arranged in fluid communication with and extends between the in-door condenser and the cooling air exhaust vent.

[0018] In accordance with another aspect, the laundry appliance includes a drying air circulation duct, a drying air circulation fan, and a heater. The drying air circulation duct is mounted inside the cabinet and includes a duct inlet and a duct outlet that are arranged in fluid communication with the laundry compartment. The drying air circulation fan is mounted inside the drying air circulation duct and is configured to pull air in through the duct inlet and push air out through the duct outlet to generate a drying air circulation flow path through the drying air circulation duct. The heater is positioned inside the drying air circulation duct for heating air inside the drying air circulation duct upstream of the duct outlet. In accordance with this aspect of the present disclosure, the air intake flow path into the in-door cavity, the return air flow path out of the in-door cavity, and the air cooling loop of the in-door condenser are separate and independent of the drying air circulation flow path.

[0019] In accordance with another aspect, the air cooling loop of the in-door condenser is a tube that extends in a flat spiral to form multiple loops that are arranged in a condenser loop plane such that the loops have a curvature that gradually increases in radius as the air cooling loop extends outwardly. In accordance with this aspect of the present disclosure, the condenser loop plane may be arranged substantially parallel to an outer surface of the front appliance door, or in other words, the condenser loop plane may be oriented in a substantially vertical orientation.

[0020] In accordance with another aspect, the laundry appliance includes a sump that is positioned in the cabinet and a water return line, in the front appliance door, that is arranged to collect water that has condensed inside the in-door cavity and carry the condensed water to the sump of the laundry appliance.

[0021] Advantageously, the in-door condensing systems described herein improve the drying performance of the washer and dryer combination laundry appliance by reducing the humidity of the air inside the laundry compartment, which is heated and recirculated during a drying cycle. Improved drying performance is realized because warm dry air provides better drying performance than warm moist air. In addition, the in-door condensing systems described herein utilize the space within the bowl of the front appliance door, which is normally wasted space.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Other advantages of the present disclosure will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a front perspective view of an exemplary washer and dryer combination laundry appliance that has been constructed in accordance with one aspect of the present disclosure;

Figure 2 is a side cross-section view of the exemplary washer and dryer combination laundry appliance shown in Figure 1;

Figure 3 is a side perspective view of the exemplary washer and dryer combination laundry appliance shown in Figure 1, where certain components of the laundry appliance have been made transparent and/or converted to dashed lines for illustration purposes;

Figure 4 is a front elevation view of an exemplary front appliance door sub-assembly having a condenser that has been constructed in accordance with an aspect of the present disclosure;

Figure 5 is a rear perspective view of the exemplary front appliance door sub-assembly shown in Figure 4 where the condenser, partition, in-door circulation fan, and heat exchanger fan are shown in dashed lines;

Figure 6 is a side cross-section view of the exemplary front appliance door sub-assembly shown in Figure 4;

Figure 7 is a front perspective view of another exemplary washer and dryer combination laundry appliance that has been constructed in accordance with another aspect of the present disclosure;

Figure 8 is a side cross-section view of the exemplary washer and dryer combination laundry appliance shown in Figure 7;

Figure 9 is a front elevation view of another exemplary front appliance door sub-assembly having a condenser that has been constructed in accordance with another aspect of the present disclosure;

Figure 10 is a rear perspective view of the exemplary front appliance door sub-assembly shown in Figure 9 where the condenser, partition, and in-door circulation fan are shown in dashed lines; and

Figure 11 is a side cross-section view of the exemplary front appliance door sub-assembly shown in Figure 9.

DETAILED DESCRIPTION

[0023] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, various aspects of a washer and dryer combination laundry appliance 20, 20' are illustrated.

[0024] Example embodiments will now be described more fully with reference to the accompanying drawings. Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be

apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

[0025] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0026] When an element or layer is referred to as being "on," "engaged to," "connected to," or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to," "directly connected to," or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0027] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as "first," "second," and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0028] For purposes of description herein the terms "up," "down," "above," "below," "upper," "lower," "top," "bottom," "front," "rear," and derivatives thereof shall relate to the assembly as oriented in Figures 1-11. However, it is to be understood that the apparatus and assemblies described herein may assume various alternative orientations. Finally, the term "substantially" as used herein describes angles and/or orientations that can vary plus or minus five degrees from the referenced direction, axis, plane, or orientation.

[0029] With reference to Figures 1-3, a laundry appliance **20** having a front-load configuration is illustrated. The laundry appliance **20** includes a cabinet **22** that is rectangular in shape and that includes a front opening **24**. A front appliance door **26** is pivotally connected to the laundry appliance **20**. The front appliance door **26** swings between an open position and a closed position. In the closed position, the front appliance door **26** shuts or closes the front opening **24** in the cabinet **22**. Although other configurations are possible, in the illustrated example, the front appliance door **26** is pivotally mounted to the front of the cabinet **22** by a hinge **28** and held in the closed position during wash and drying cycles by a latch **29**.

[0030] The front appliance door **26** includes an outer wall **30** that presents an outer door surface **31**, which faces out away from the front opening **24** in the cabinet **22** when the front appliance door **26** is in the closed position and an inner wall **32** that faces the front opening **24** in the cabinet **22** when the front appliance door **26** is in the closed position. The front appliance door **26** also includes a door perimeter **33** and a bowl **34**. The door perimeter **33** is configured to abut the cabinet **22** when the front appliance door **26** is in the closed position. The bowl **34** is provided on the inner wall **32** of the front appliance door **26** and is spaced radially inward of the door perimeter **33**. At least a portion of the bowl **34** is received in the front opening **24** in the cabinet **22** when the front appliance door **26** is in the closed position. Among other functions, the bowl **34** prevents laundry inside the laundry appliance **20** from accumulating in the front opening **24** during tumbling and particularly during the wash cycle of the laundry appliance **20**. Although other materials can be used, in the illustrated example, the front appliance door **26** is made of metal, while the bowl **34** is made of a molded plastic material. Portions of the bowl **34** are spaced from the front appliance door **26** such that an indoor cavity **35** is defined between the outer wall **30** and the inner wall **32** of the front appliance door **26**.

[0031] The laundry appliance **20** includes a drum housing **36** with a cylindrical shape that is mounted inside the cabinet **22** on dynamic mounts **38**, which keep the drum housing **36** from rotating, but permit limited degrees of freedom that allow the drum housing **36** to move/oscillate relative to the cabinet **22** during tumbling. The drum housing **36** includes a front ring **40**, a rear drum housing wall **42**, and a drum housing sidewall **44** that extends longitudinally from the front ring **40** to the rear drum housing wall **42** to define a drum housing cavity **46** inside the drum housing **36**. The front ring **40** of the drum housing **36** includes a drum housing opening **48** positioned in at least partial alignment with the front opening **24** in the cabinet **22**.

[0032] A drum **50** is positioned in the drum housing cavity **46** and is supported therein such that the drum **50** is rotatable with respect to the drum housing **36** about a longitudinal axis **52**. The drum **50** also has a cylindrical shape and extends longitudinally between a front drum end **54** and a rear drum end **56**. The drum **50** includes a drum opening **58** at the front drum end **54**, a rear drum wall **60** at the rear drum end **56**, and a drum sidewall **62** that extends longitudinally between the front and rear drum ends **54**, **56**. The drum sidewall **62** includes an outer surface **64** that faces the drum housing sidewall **44**. The front drum end **54**, the drum sidewall **62**, and the rear drum wall **60** cooperate to define a laundry compartment **66** inside the drum **50**. The front opening **24** in the cabinet **22**, the drum housing opening **48** in the front ring **40** of the drum housing **36**, and the drum opening **58** at the front drum end **54** are at least partially aligned with one another and therefore provide access to the laundry compartment **66** inside the drum **50** when the front appliance door **26** is in the open position. Thus, it should be appreciated that in use, laundry (e.g., clothes, towels, and/or bedding, etc.) is placed inside the laundry compartment **66** where it is first cleaned during the wash cycle and then dried during the drying cycle of the laundry appliance **20**.

[0033] A drive shaft **68**, fixedly coupled to the rear drum end **56**, is supported by a bearing pack **70** such that the drive shaft **68** and the drum **50** rotate together as a single unit within the cabinet **22**. An electric motor **72**, positioned in the cabinet **22**, operates to drive rotation of the drive shaft **68**, which in turn drives rotation of the drum **50** within the drum housing **36** and the cabinet **22** during operation of the laundry appliance **20**, such as during washing and tumbling.

[0034] As best seen in Figure 3, the laundry appliance **20** includes a drying air circulation duct **74**, which is mounted inside the cabinet **22**. The drying air circulation duct **74** includes a duct inlet **76** and a duct outlet **78** that are arranged in fluid communication with the laundry compartment **66**. A drying air circulation fan **80** is mounted inside the drying air circulation duct **74**. During a drying cycle of the laundry appliance **20**, the drying air circulation fan **80** pulls air in the laundry compartment **66** in through the duct inlet **76** and pushes air out through the duct outlet **78** to define a drying air circulation flow path **82** through the drying air circulation duct **74**. A heater **84** is also positioned inside the drying air circulation duct **74**. Although other configurations are possible, the heater **84** may be an electric resistance heater, for example. During one or more portions of the drying cycle, the heater **84** operates to heat the air inside the drying air circulation duct **74** upstream of the duct outlet **78**. When the heater **84** is activated, the temperature of the air expelled into the laundry compartment **66** from the duct outlet **78** is warmer (i.e., is at a higher temperature) than the air that is pulled into the drying air circulation duct **74** through the duct inlet **76**. The circulation and heating of air performed by the drying air circulation duct **74** during a drying cycle of the laundry appliance **20** dries the laundry in the laundry compartment **66** as it tumbles within the rotating drum **50**. However, as the laundry dries, the air inside the laundry compartment **66** that is re-circulated through the drying air circulation duct **74** becomes very humid (i.e., moist).

[0035] To improve drying performance, the laundry appliance **20** further includes an in-door condensing system **86** that is mounted within the in-door cavity **35**. The in-door condensing system **86** operates to remove some of the humidity (i.e., moisture) from the air in the laundry compartment **66** through condensation to improve the drying performance of the laundry appliance **20**. The space in the front appliance door **26** that is taken up by the bowl **34** is normally wasted. Advantageously, the in-door condensing system **86** described herein makes use of this otherwise wasted space.

[0036] With additional reference to Figures 4-6, the in-door condensing system **86** includes an in-door condenser **88**, an air inlet **90**, an air outlet **92**, and an in-door circulation fan **94**, and a heat exchanger fan **96**. The in-door condenser **88** is positioned in the in-door cavity **35**. The in-door condenser **88** is arranged as an air-to-air heat exchanger and includes an air cooling loop **98** that is positioned inside the in-door cavity **35**. In the examples illustrated, the air cooling loop **98** of the in-door condenser **88** is formed of a metal tube that extends in a flat spiral to form multiple loops that are arranged in a condenser loop plane **146**. The loops of the in-door condenser **88** have a curvature that gradually increases in radius as said air cooling loop **98** extends out towards the door perimeter **33**. The in-door condenser **88** is mounted inside the in-door cavity **35** of the front appliance door **26** in an orientation where the condenser loop plane **146** is arranged in a substantially vertical orientation and is substantially parallel to the outer door surface **31**. However, it should be appreciated that alternative configurations and geometries for the in-door condenser **88** are possible and are considered to be within the scope of the present disclosure.

[0037] The bowl **34** in the inner wall **32** of the front appliance door **26** has a dome-shaped depression **148** and a partition **150**, attached to the bowl **34**, that extends from the bowl **34** towards the in-door condenser **88** to divide at least part of the in-door cavity **35** into a first zone **152** and a second zone **154**. The air inlet **90** and the air outlet **92** are positioned in different zones **152**, **154** of the in-door cavity **35** such that the partition **150** directs airflow inside the in-door cavity **35** past the in-door condenser **88** before exiting through the air outlet **92**. Although other configurations are possible, in the illustrated example, the air inlet **90** is positioned in fluid communication with the first zone **152** of the in-door cavity **35** and the air outlet **92** is positioned in fluid communication with the second zone **154** of the in-door cavity **35**. In other words, the air inlet **90** extends through the bowl **34** at a location that is positioned above the air outlet **92**. However, it should be appreciated that this arrangement may be reversed,

where the air inlet **90** is positioned below the air outlet **92** or where the air inlet **90** and the air outlet **92** are positioned on opposite sides of the bowl **34** with the partition extending vertically instead of horizontally like in the illustrated examples.

[0038] In the illustrated example, the in-door circulation fan **94** is positioned in the second zone **154** of the in-door cavity **35** adjacent to the air outlet **92** and is mounted to the bowl **34**. However, it should be appreciated that other configurations are possible. For example, the in-door circulation fan **94** is positioned in the first zone **152** of the in-door cavity **35** adjacent to the air inlet **90** or at a location in the in-door cavity **35** that is spaced from the air inlet **90** and air outlet **92**. Regardless of the location, the in-door circulation fan **94** operates to draw moist air from the laundry compartment **66** into the in-door cavity **35** along an air intake flow path **132** (shown in Figure 6) and expel dry air from the in-door cavity **35** back into the laundry compartment **66** along a return air flow path **134** (also shown in Figure 6). The in-door circulation fan **94** circulates the moist air from inside the laundry compartment **66** through the in-door cavity **35** and past the air cooling loop **98** of the in-door condenser **88** to facilitate condensation in the in-door cavity **35**.

[0039] While other configurations are possible, in the illustrated examples, the air inlet **90** and the air outlet **92** are provided in the form of a plurality of holes **140a, 140b** that extend through the bowl **34** where the group of holes **140a** forming the air inlet **90** are positioned below the group of holes **140b** forming the air outlet **92**. Referring back to Figure 3, it should be appreciated that the air intake flow path **132** into the in-door cavity **35** and the return air flow path **134** out of the in-door cavity **35** are separate and independent of the drying air circulation flow path **82**.

[0040] The heat exchanger fan **96** of the in-door condensing system **86** is positioned in the in-door cavity **35** and is arranged to pull cooling air from outside the laundry appliance **20** (i.e., the ambient air outside the cabinet **22**) into the air cooling loop **98** of the in-door condenser **88** through a cooling air intake **100** located in the outer wall **30** of the front appliance door **26** near the door perimeter **33** at the twelve o'clock position. As shown by the arrows in Figure 6, after the cooling air travels through the air cooling loop **98** of the in-door condenser **88** it is expelled out of the front appliance door **26** into the ambient environment surrounding the laundry appliance **20** through a cooling air exhaust vent **102** located in the outer wall **30** of front appliance door **26** near the door perimeter **33** at the six o'clock position. Thus, both the cooling air intake **100** and the cooling air exhaust vent **102** are located in the outer wall **30** of the front appliance door **26** and are open to ambient air outside of the cabinet **22**. However, it should be appreciated that the exact location and placement of the cooling air intake **100** and cooling air exhaust vent **102** may vary from the locations shown and described herein.

[0041] The in-door condensing system **86** further includes a cooling air intake duct 106 and a cooling air exhaust duct **108**. The cooling air intake duct **106** is located in the front appliance door **26** and extends between the cooling air intake **100** and the in-door condenser **88**. The cooling air exhaust duct **108** is also located in the front appliance door **26** and extends between the in-door condenser **88** and the cooling air exhaust vent **102**. In the illustrated example, the in-door circulation fan **94** is arranged in fluid communication with the cooling air intake duct **106** for drawing ambient air in through the cooling air intake **100** and is mounted to the partition **150**. However, it should be appreciated that the in-door circulation fan **94** could be placed in other locations, including in locations where the in-door circulation fan **94** is arranged in fluid communication with the cooling air exhaust duct **108** or the in-door condenser **88**.

[0042] As shown in Figures 2 and 6, the front appliance door **26** includes a water drain line **104** that is arranged in fluid communication with the in-door cavity **35** such that the water drain line **104** is configured to collect the water that has condensed out of the moist air that has been pulled into the in-door cavity **35** by the in-door circulation fan **94**. This water that has condensed (i.e., the water condensate) falls into the bottom of the in-door cavity **35** under the influence of gravity and is carried back to the cabinet **22** via the water drain line **104**, which is connected in fluid communication with a water return line **126** in the cabinet **22** by a water outlet joint **116** that is created between the front appliance door **26** and the cabinet **22** when the front appliance door **26** is in the closed position. The water return line **126** receives water condensate from the water drain line **104** and carries it to a sump **120** of the laundry appliance **20**, which is located at the bottom of the cabinet **22**, beneath the drum **50**.

[0043] Figures 7-11 illustrate another exemplary laundry appliance **20'** that includes another in-door condensing system **86'** in which the in-door condenser **88'** is constructed to receive a cooling air flow from the cabinet **22'**. Many of the elements of the laundry appliance **20'** shown in Figures 7-11 are the same or similar to the elements of the laundry appliance **20** shown in Figures 1-6 and therefore share the same reference numbers, but have been annotated with a prime symbol (') after the reference numerals. Figures 7-11 illustrate an alternative configuration, where the laundry appliance **20'** includes a chiller **130'** (i.e., an air-to-air, air-to-water, or air-to-refrigerant heat exchanger) located inside the cabinet **22'** that supplies a cooling air flow to the air cooling loop **98'** of the in-door condenser **88'**, which again is arranged as an air-to-air heat exchanger.

[0044] With reference to Figures 7 and 8, the chiller **130'** is located inside the cabinet **22'** and is arranged upstream of the air cooling loop **98'** of the in-door condenser **88'**. An outside air inlet **136'** is located at the rear of the cabinet **22'**. The heat exchanger fan **96'** is also located at the rear of the cabinet **22'** and is positioned adjacent to the outside air inlet **136'**, which is open to the

ambient air outside of the cabinet **22'**. In operation, the heat exchanger fan **96'** draws the cool ambient air in from outside of the cabinet through the outside air inlet **136'** and into an outside air duct **138'** that is located inside the cabinet **22'** and that extends between the outside air inlet **136'** and an inlet side **142'** of the chiller **130'**. A cool air duct **156'** is located in the cabinet **22'** that extends between an outlet side **144'** of the chiller and a cooling air joint **158'** that is positioned at the front of the cabinet **22'** adjacent to the front opening **24'.**

[0045] Although other configurations are possible, in the illustrated example, the chiller **130'** is an air-to-refrigerant heat exchanger. Accordingly, a compressor **160'**, located in the cabinet **22'**, is connected to the chiller **130'** by refrigerant lines **162a', 162b'** that circulate a refrigerant (such as R134a, for example) between the compressor **160'** and the chiller **130'** to extract heat from the cooling air flow as it passes from the inlet side **142'** of the chiller **130'** to the outlet side **144'** of the chiller **130'**. It should also be appreciated that although the heat exchanger fan **96'** in the illustrated example is arranged in fluid communication with the outside air duct **138'** at the rear of the cabinet **22'**, the heat exchanger fan **96'** may be placed in other locations, including in fluid communication with the cool air duct **156'** or the chiller **130'**.

[0046] With additional reference to Figures 9-11, a cooling air intake **100'** is located in the inner wall **32'** of the front appliance door, which is connected in fluid communication with the cool air duct **156'** by the cooling air joint **158'** that is created between the front appliance door **26'** and the cabinet **22'** when the front appliance door **26'** is in the closed position. As shown by the arrows in Figure 11, the air cooling loop **98'** of the in-door condenser **88'** receives the cooling air flow from the cool air duct **156'** after it has been cooled by the chiller **130'**. The in-door condensing system **86'** includes a cooling air intake duct **106'** located in the front appliance door **26'** that extends between the cooling air intake **100'** and the in-door condenser **88'**. The front appliance door **26'** also includes a cooling air exhaust vent **102'** located in the outer wall **30'** of the front appliance door **26'**, which is open to the ambient air outside of the cabinet **22'**. The in-door condensing system **86'** further includes a cooling air exhaust duct **108'** that is positioned in the front appliance door **26'** and that extends between the in-door condenser **88'** and the cooling air exhaust vent **102'**. Because the heat exchanger fan **96'** is positioned inside the cabinet **22'** in accordance with this embodiment, only one fan - the in-door circulation fan **94'** - is positioned inside the in-door cavity **35'**. In accordance with the embodiment illustrated in Figures 7-11, the cooling air intake **100'** is located in the inner wall **32'** of the front appliance door **26'** near the door perimeter **33'** at the six o'clock position and the cooling air exhaust vent **102'** is located in the outer wall **30'** of front appliance door **26'** near the door perimeter **33'** at the twelve o'clock position. However, it should be appreciated that the exact location and placement of the cooling air intake **100'** and cooling air exhaust vent **102'** may vary from the locations shown and described herein.

[0047] Many modifications and variations of the apparatus and assemblies described in the present disclosure are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the appended claims. These antecedent recitations should be interpreted to cover any combination in which the inventive novelty exercises its utility.

Claims

1. A laundry appliance (20), comprising:

a cabinet (22) with a front opening (24);
a drum (50) rotatably supported within said cabinet (22), said drum (50) including a laundry compartment (66) that is accessible through said front opening (24) in said cabinet (22);
a front appliance door (26) pivotally mounted with respect to said cabinet (22) such that said front appliance door (26) is configured to swing between a closed position where said front appliance door (26) closes said front opening (24) in said cabinet (22) and an open position where said front appliance door (26) is swung away from said front opening (24);
said front appliance door (26) includes a bowl (34) that is positioned on said front appliance door (26) such that at least a portion of said bowl (34) extends into said front opening (24) in said cabinet (22) when said front appliance door (26) is in said closed position;
said bowl (34) defining an in-door cavity (35) within said front appliance door (26);
an in-door condensing system (86) mounted within said in-door cavity (35); and
said in-door condensing system (86) including an in-door condenser (88), arranged as an air-to-air heat exchanger, that includes an air cooling loop (98) that is positioned inside said in-door cavity (35); and
an in-door circulation fan (94), positioned in said in-door cavity (35), that is arranged to pull moist air from inside said laundry compartment (66) into said in-door cavity (35) and past said air cooling loop (98) of said in-door condenser (88) to facilitate condensation in said in-door cavity (35) and remove moisture from said laundry compartment (66).

2. The laundry appliance (20) as set forth in claim 1, wherein said in-door condensing system (86) includes an air inlet (90) positioned in said bowl (34) to define an air intake flow path (132) along which moist air flows directly from said laundry compartment (66) into said in-door cavity (35) and an air out-

let (92) positioned in said bowl (34) to define a return air flow path (134) along which dry air from inside said in-door cavity (35) flows directly into said laundry compartment (66).

3. The laundry appliance (20) as set forth in claim 2, further comprising:
a partition (150) that extends from said bowl (34) towards said in-door condenser (88) to divide at least part of said in-door cavity (35) into first and second zones (152, 154).

4. The laundry appliance (20) as set forth in claim 3, wherein said air inlet (90) and said air outlet (92) are positioned in different zones (152, 154) of said in-door cavity (35) such that said partition (150) directs airflow inside said in-door cavity (35) past said in-door condenser (88) before exiting through said air outlet (92).

5. The laundry appliance (20) as set forth in claim 4, wherein heat exchanger fan (96) positioned in the same zone as said air outlet (92).

6. The laundry appliance (20) as set forth in claim 2, further comprising:

a cooling air intake (100) located in said front appliance door (26) that is open to ambient air outside of said cabinet (22);
a cooling air intake duct (106) located in said front appliance door (26) that is arranged in fluid communication with and that extends between said cooling air intake (100) and said in-door condenser (88);
a cooling air exhaust vent (102) located in said front appliance door (26) that is open to ambient air outside of said cabinet (22); and
a cooling air exhaust duct (108) located in said front appliance door (26) that is arranged in fluid communication with and that extends between said in-door condenser (88) and said cooling air exhaust vent (102),
wherein said in-door circulation fan (94) is arranged in fluid communication with at least one of said cooling air intake duct (106), said cooling air exhaust duct (108), and said in-door condenser (88) for drawing said ambient air in through said cooling air intake duct (106).

7. The laundry appliance (20) as set forth in claim 1, further comprising:
a chiller (130) located inside said cabinet (22) and arranged to supply a cooling air flow to said air cooling loop (98).

8. The laundry appliance (20) as set forth in claim 7, wherein said chiller (130) is an air-to-refrigerant heat exchanger and wherein said cooling air flow that said chiller (130) supplies to said air cooling loop (98) of said in-door condenser (88) is expelled through a cooling air exhaust vent (102) located in said front appliance door (26).

9. The laundry appliance (20) as set forth in claim 8, further comprising:

an outside air inlet (136) located in said cabinet (22) that is open to ambient air outside of said cabinet (22);
an outside air duct (138) located in said cabinet (22) that is arranged in fluid communication with and that extends between said outside air inlet (136) and an inlet side (142) of said chiller (130);
a compressor (160) located in said cabinet (22) that is connected to said chiller (130) by refrigerant lines (162a, 162b) that circulate refrigerant between said compressor (160) and said chiller (130);
a cool air duct (156) located in said cabinet (22) that is arranged in fluid communication with an outlet side (144) of said chiller (130);
a heat exchanger fan (96) located in said cabinet (22) that is arranged in fluid communication with at least one of said outside air duct (138), said cool air duct (156), and said chiller (130) for drawing said ambient air in through said outside air duct (138);
a cooling air intake (100) located in said front appliance door (26) that is arranged in fluid communication with said cool air duct (156) in said cabinet (22) when said front appliance door (26) is in said closed position;
a cooling air intake duct (106) located in said front appliance door (26) that is arranged in fluid communication with and that extends between said cooling air intake (100) and said in-door condenser (88); and
a cooling air exhaust duct (108) that is arranged in fluid communication with and that extends between said in-door condenser (88) and said cooling air exhaust vent (102).

10. The laundry appliance (20) as set forth in any one of claims 1-9, further comprising:

a drying air circulation duct (74) mounted inside said cabinet (22) and including a duct inlet (76) and a duct outlet (78) that are arranged in fluid communication with said laundry compartment (66);
a drying air circulation fan (80) mounted inside said drying air circulation duct (74) that is configured to pull air in through said duct inlet (76) and push air out through said duct outlet (78) to generate a drying air circulation flow path (82)

through said drying air circulation duct (74); and a heater (84) positioned inside said drying air circulation duct (74) for heating air inside said drying air circulation duct (74) upstream of said duct outlet (78).

11. The laundry appliance (20) as set forth in claim 10, wherein said air intake flow path (132) into said in-door cavity (35), said return air flow path out (134) of said in-door cavity (35), and said air cooling loop (98) of said in-door condenser (88) are separate and independent of said drying air circulation flow path (82).

12. The laundry appliance (20) as set forth in any one of claims 1-9, wherein said air cooling loop (98) of said in-door condenser (88) is a tube that extends in a flat spiral to form multiple loops arranged in a condenser loop plane (146) such that said loops have a curvature that gradually increases in radius as said air cooling loop (98) extends outwardly.

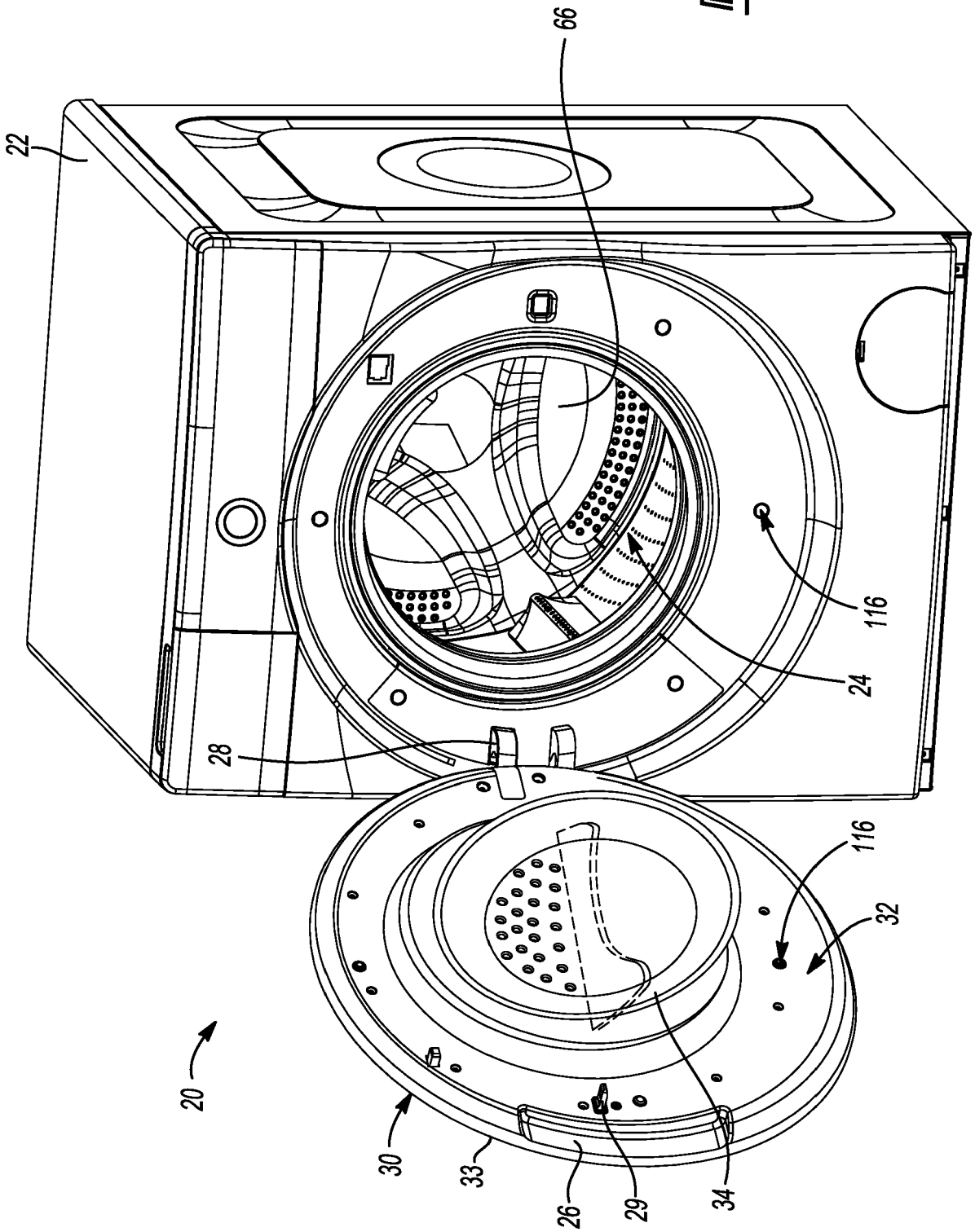
13. The laundry appliance (20) as set forth in claim 12, wherein said condenser loop plane (146) is arranged in a substantially vertical orientation.

14. The laundry appliance (20) as set forth in claim 12, wherein said front appliance door (26) has an outer door surface (31) and wherein said condenser loop plane (146) is arranged substantially parallel to said outer door surface (31).

15. The laundry appliance (20) as set forth in any one of claims 1-9, further comprising:

a sump (120) positioned in said cabinet (22); and a water return line (126) in said front appliance door (26) that is arranged to collect water that has condensed inside said in-door cavity (35) and carry said water to said sump (120).

Fig-1



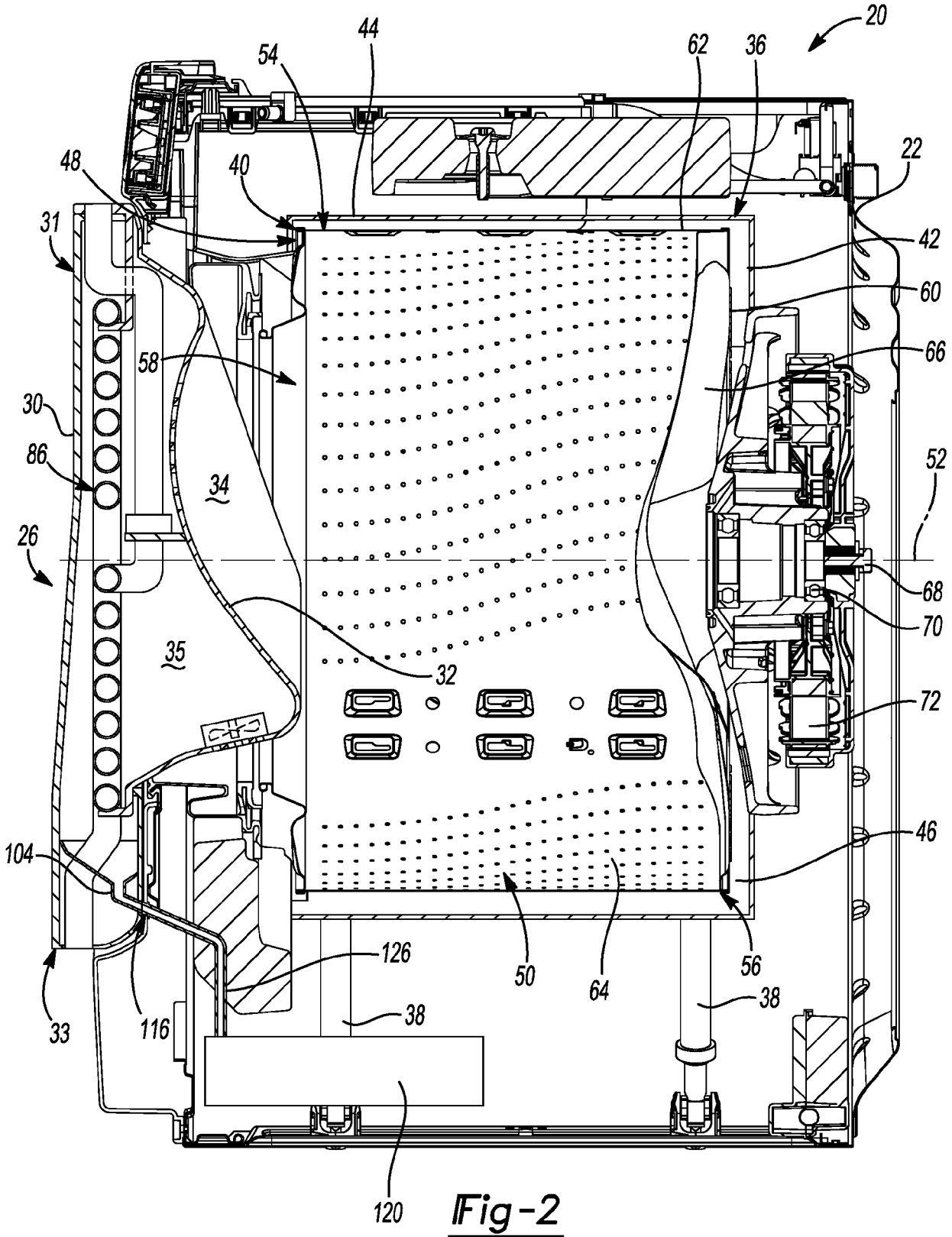

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Fig-2

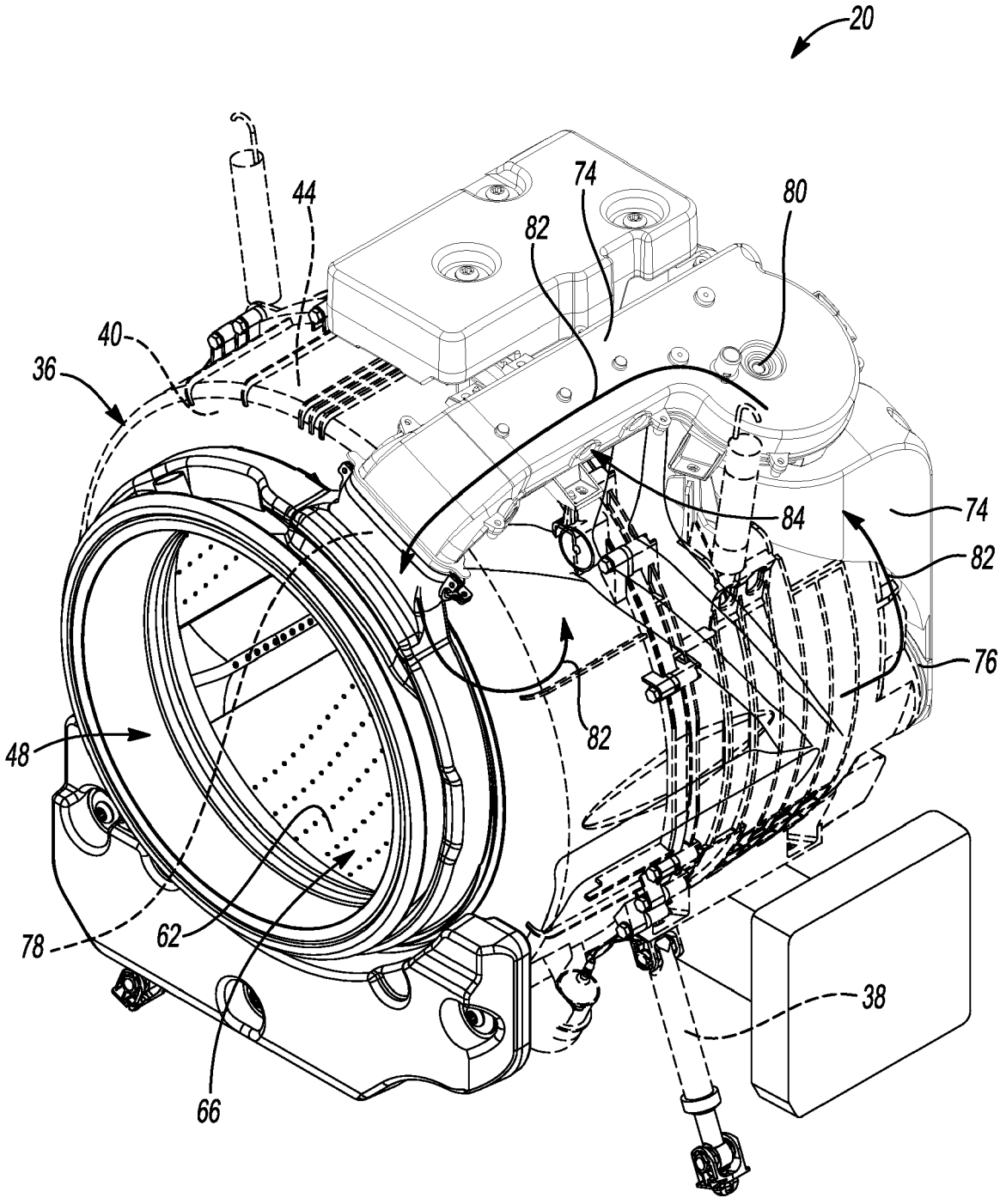

Fig-3

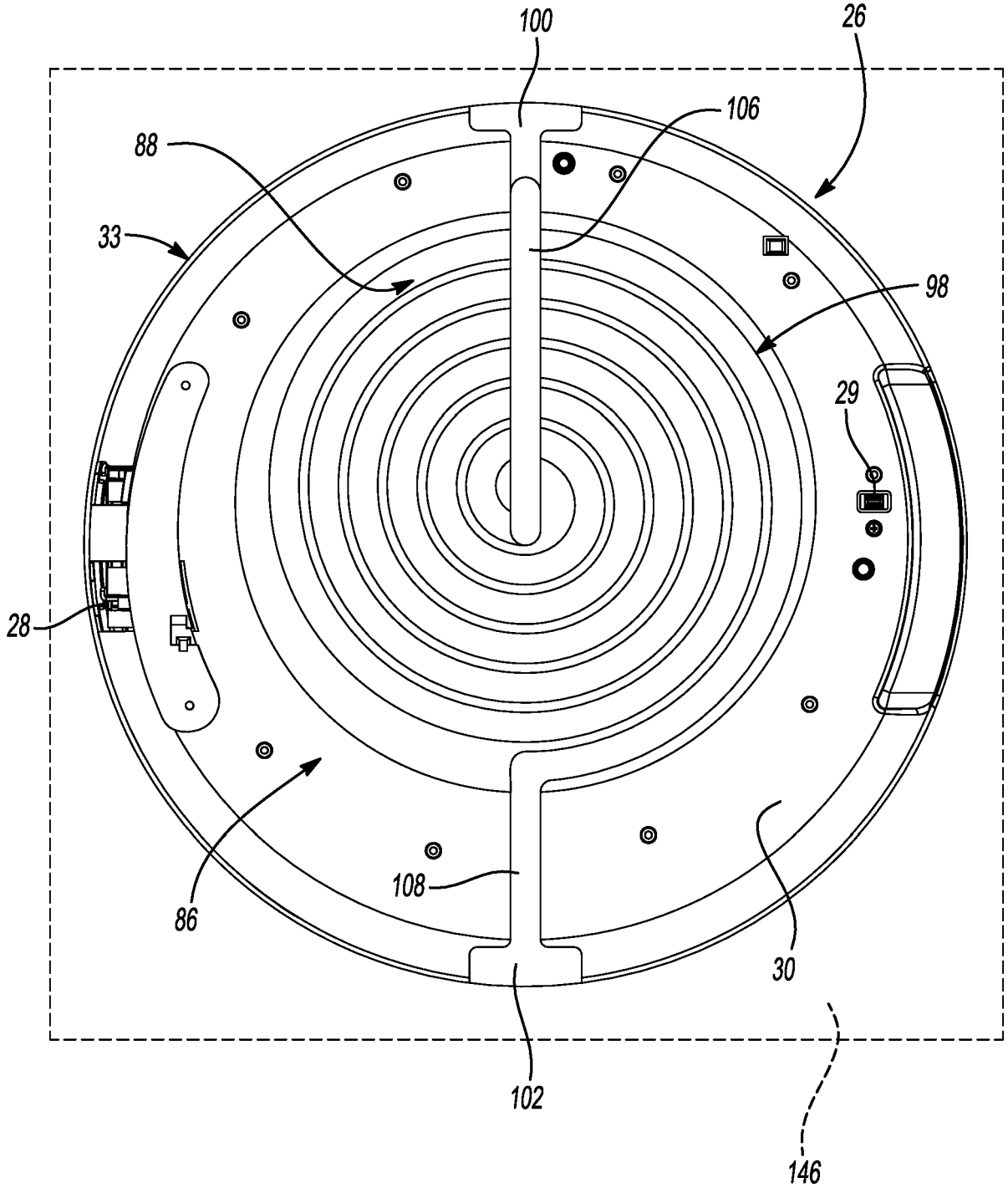

Fig -4

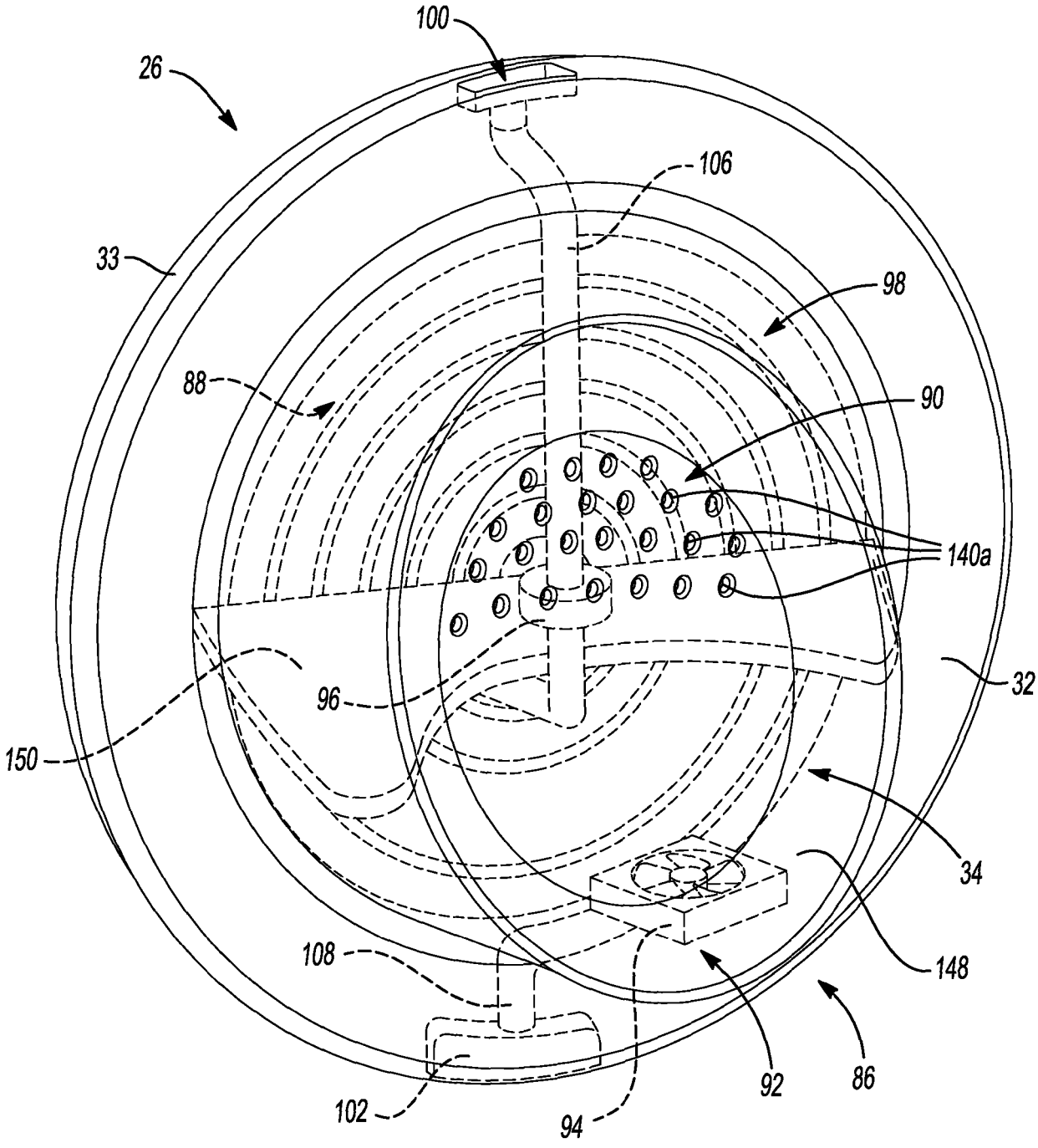

Fig-5

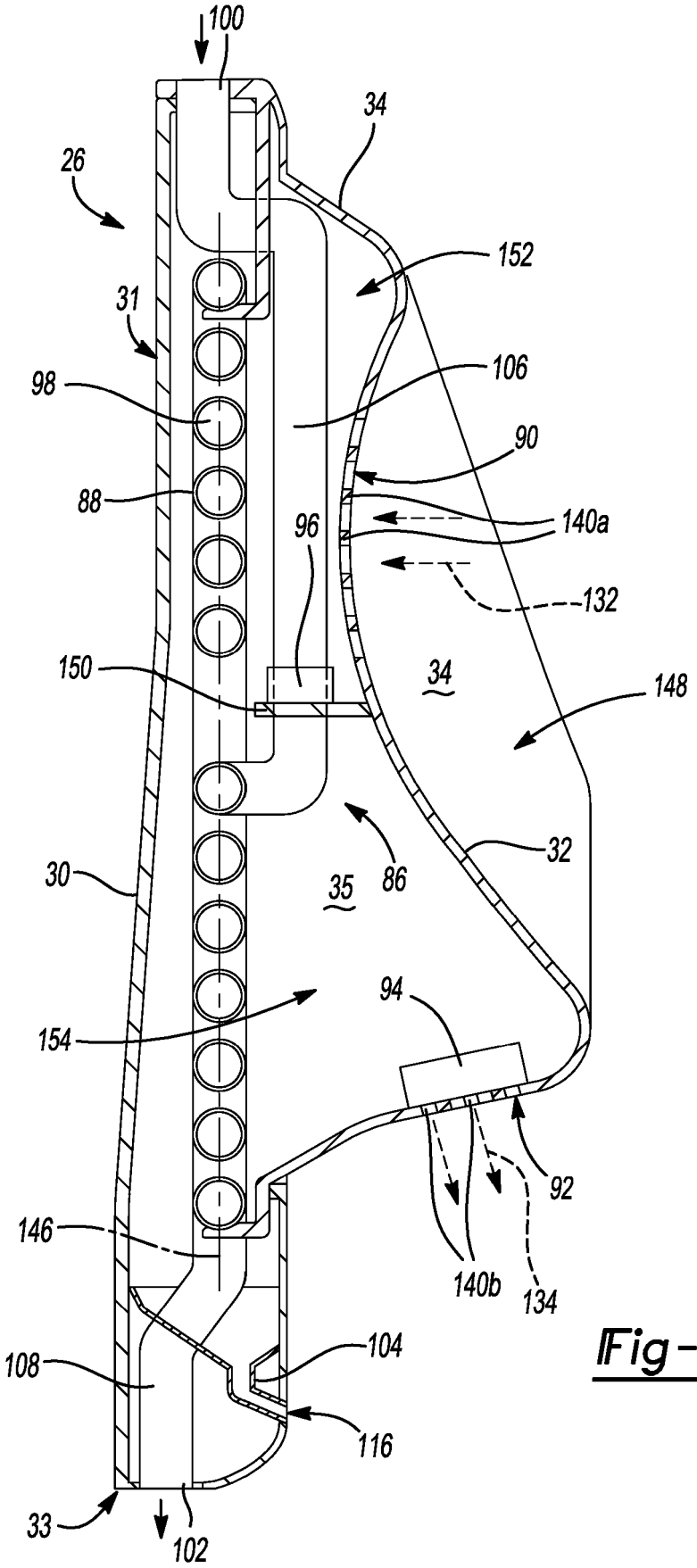
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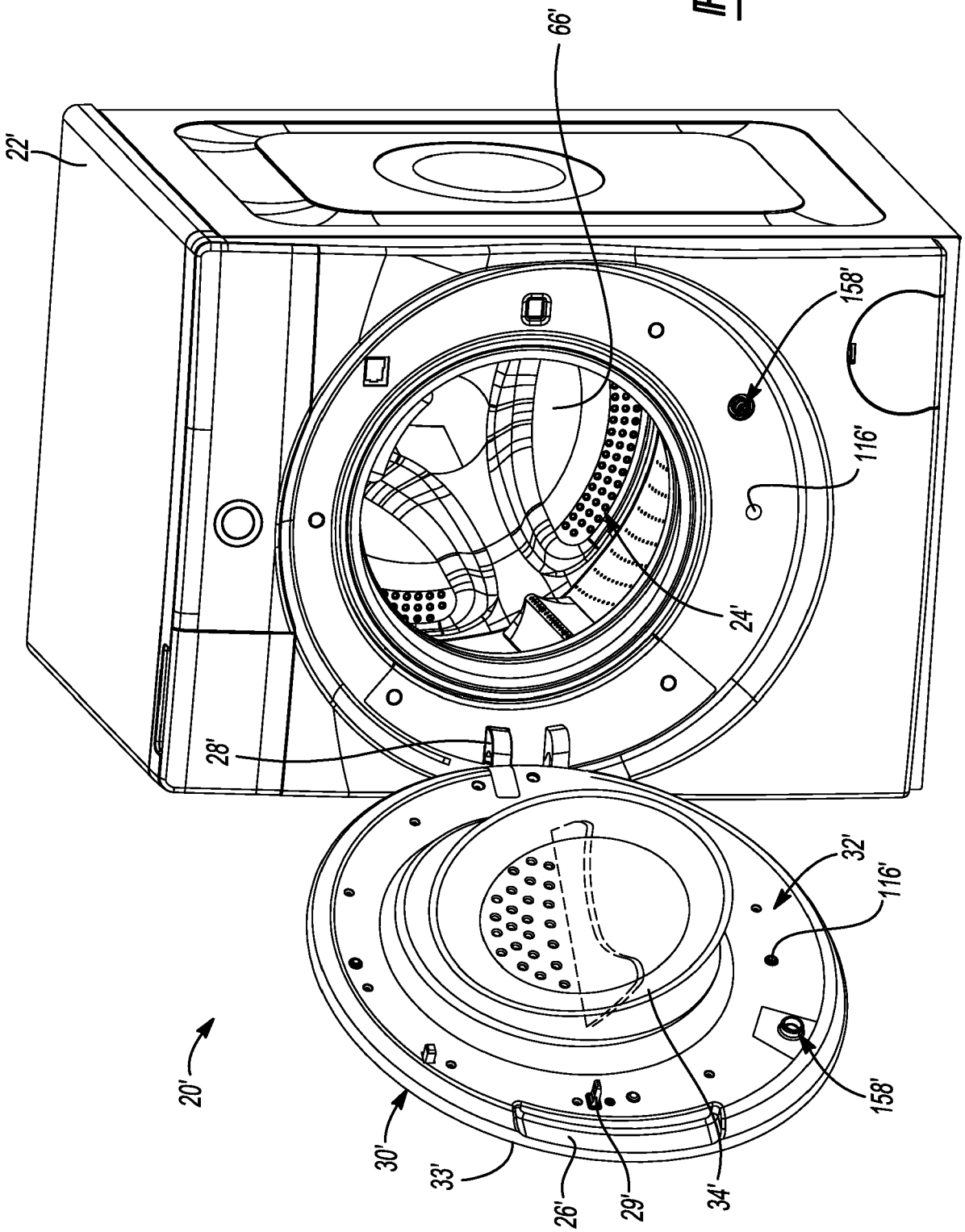
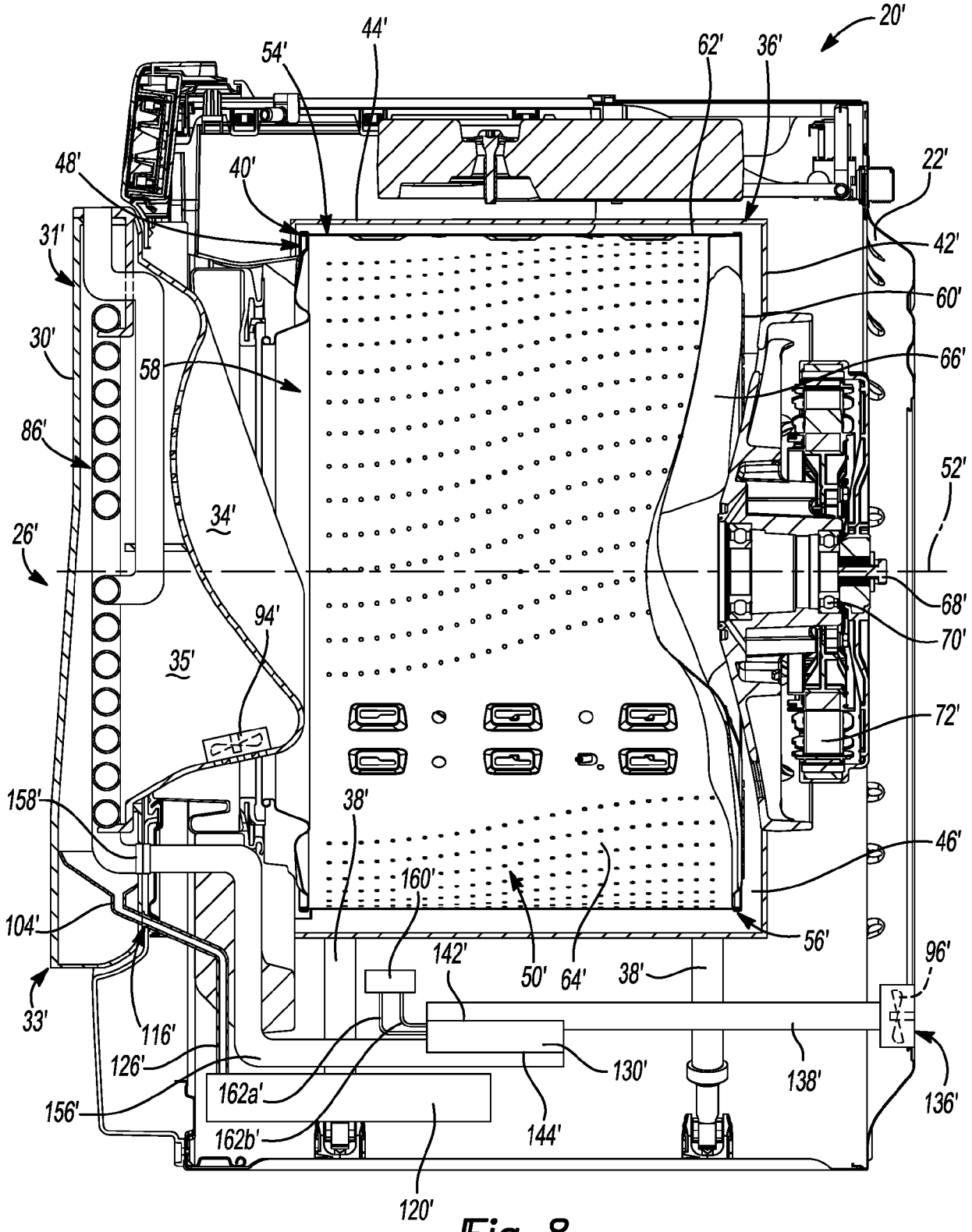
Fig-6

Fig-7

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68'
94'
70'
35'
72'
158'
38'
46'
160'
104'
56'
142'
50'
64'
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162a'
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144'
120'

Fig-8

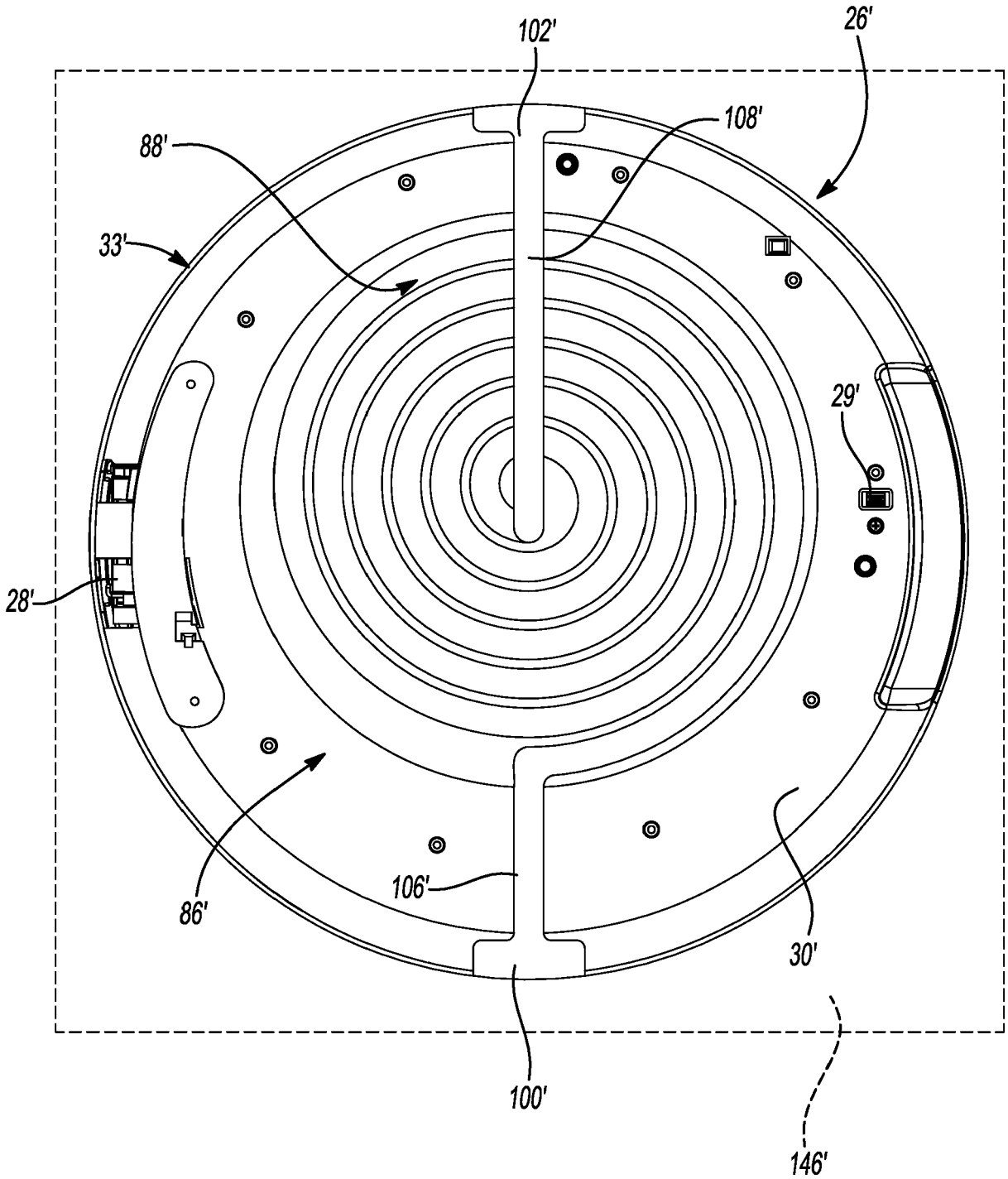


Fig-9

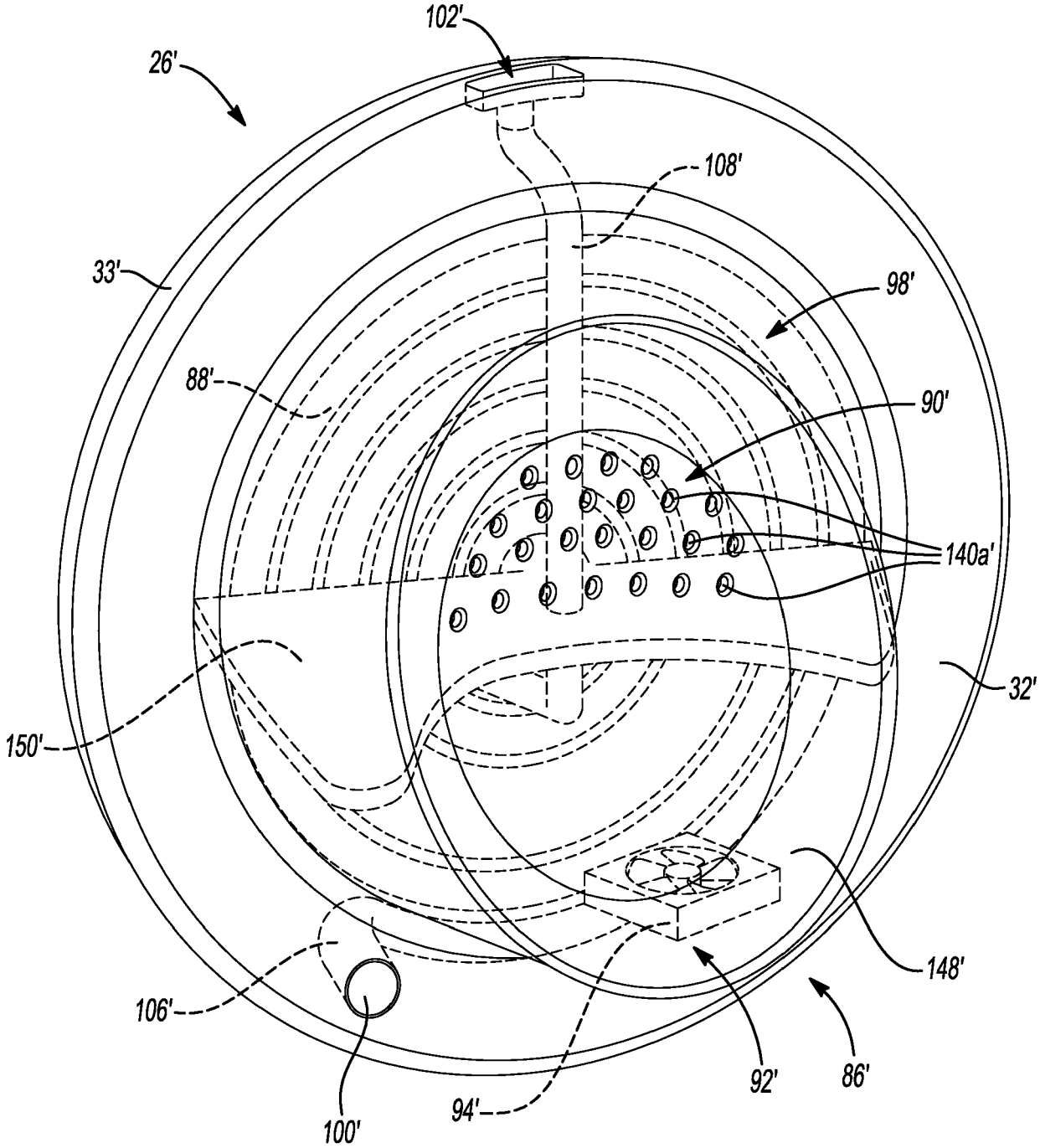
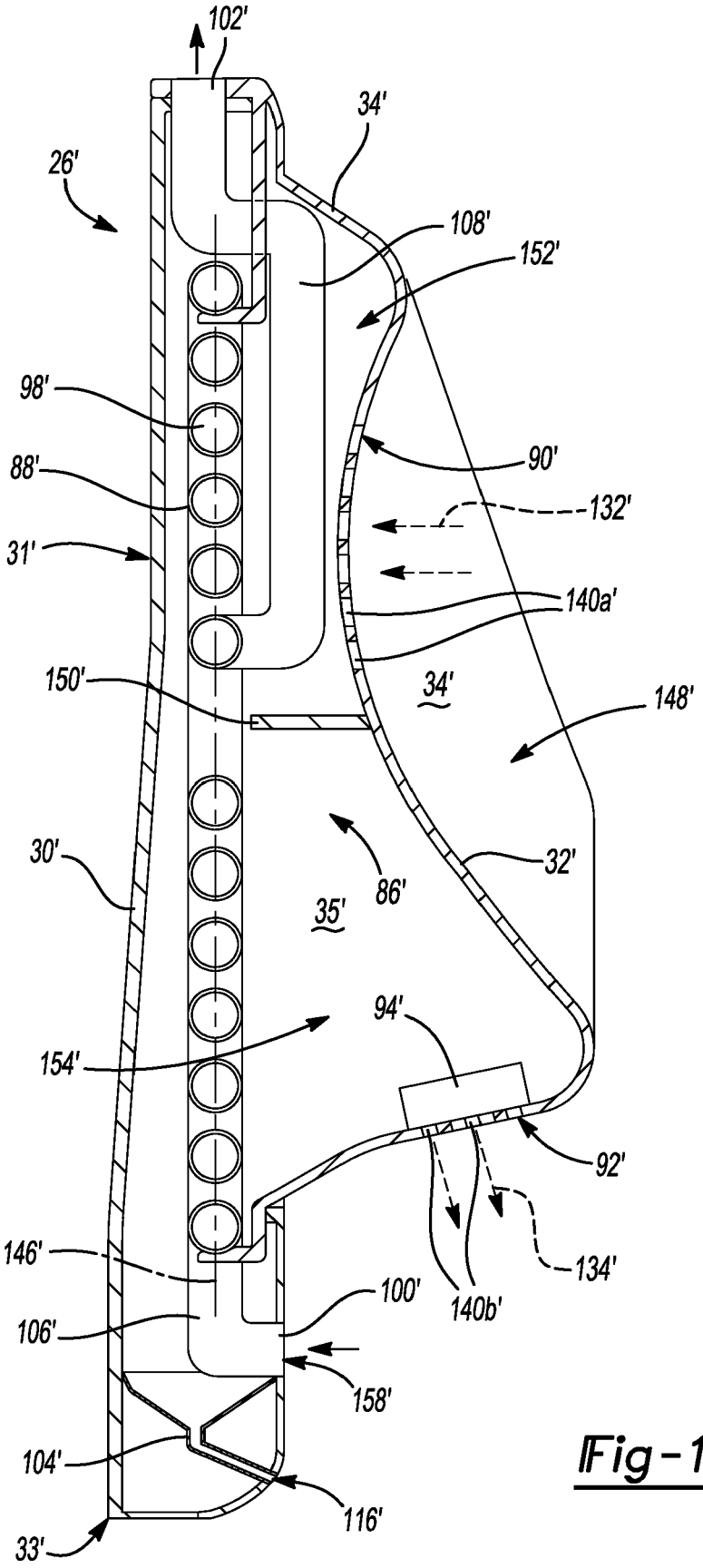


Fig-10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92'
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134'
100'
140b'
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116'
33'

Fig-11

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EUROPEAN SEARCH REPORT

Application Number
EP 22 19 6933

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D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	14 February 2023	Popara, Velimir

CATEGORY OF CITED DOCUMENTS

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