US 20250257897A1

(19) United States
(12) Patent Application Publication
Bushnell et al.

(10) Pub. No.: US 2025/0257897 A1
(43) Pub. Date: Aug. 14, 2025

(54) **AIR HANDLING UNIT HAVING A HEAT SHIELD FLOW DISTRIBUTOR**

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(21) Appl. No.: **19/192,535**

(22) Filed: **Apr. 29, 2025**

Related U.S. Application Data

(60) Provisional application No. 63/511,199, filed on Jun. 30, 2023.

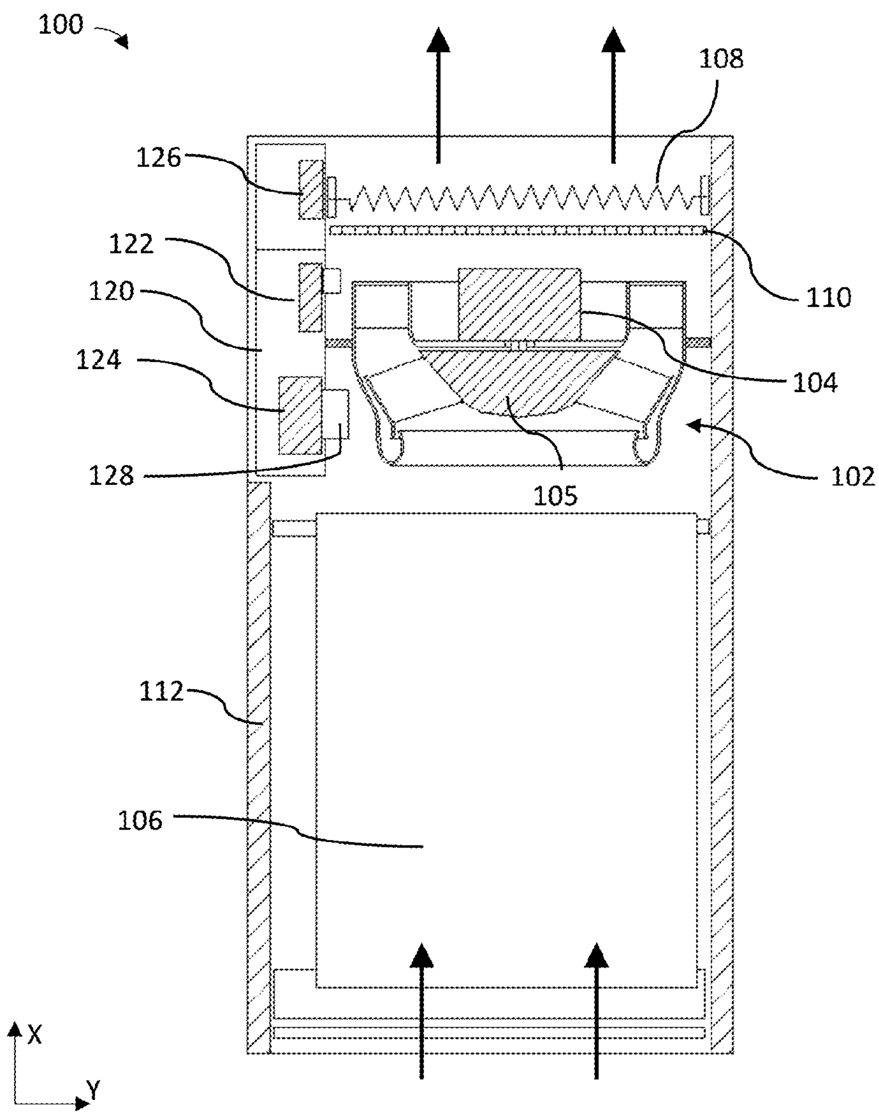
Publication Classification

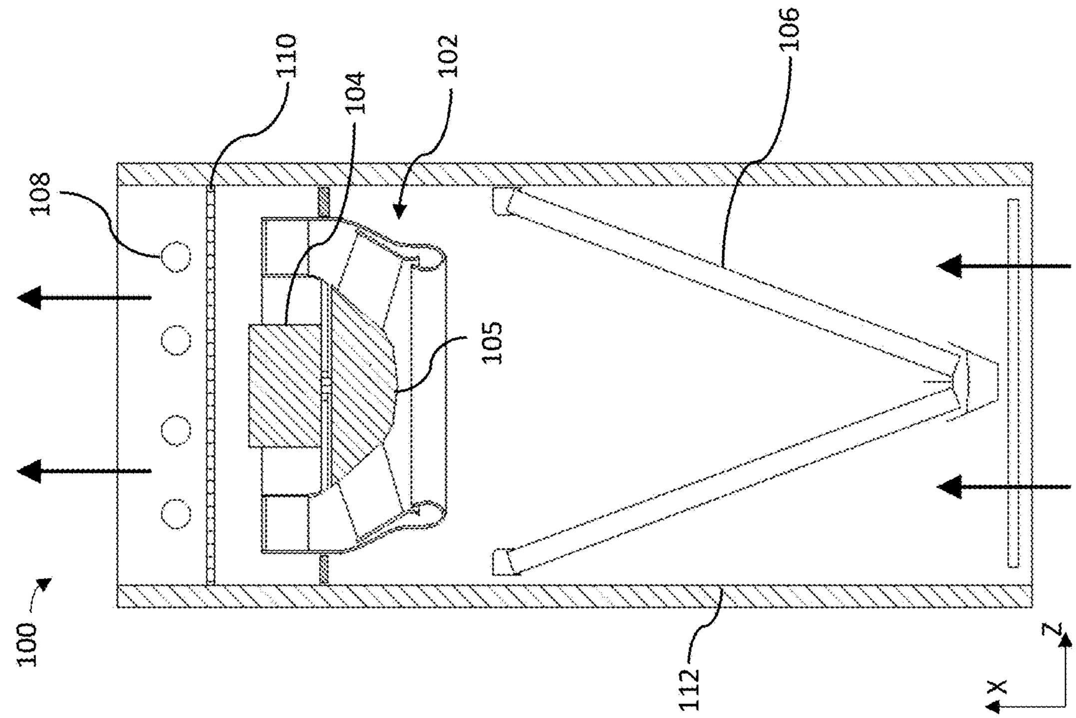
(51) **Int. Cl.**
F24F 13/02 (2006.01)

(52) **U.S. Cl.**
CPC *F24F 13/02* (2013.01)

(57) **ABSTRACT**

An air handling unit is disclosed, including a motor-driven fan with an annular outlet configured to move air through a housing of the AHU, a primary heat exchanger configured to cool or heat the air passing through the AHU, one or more heat elements placed downstream of the motor-driven fan, the one or more heat elements being configured to transfer heat to the airflow, and a heat shield placed between the motor-driven fan and the one or more heat elements, and configured to reduce heat transfer from the one or more heat elements upstream of the heat shield, and redistribute the airflow upstream and downstream of the heat shield, wherein the heat shield includes a distribution of openings configured to allow air to flow through the heat shield.




100
108
110
104
102
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X
Z

FIG. 1B

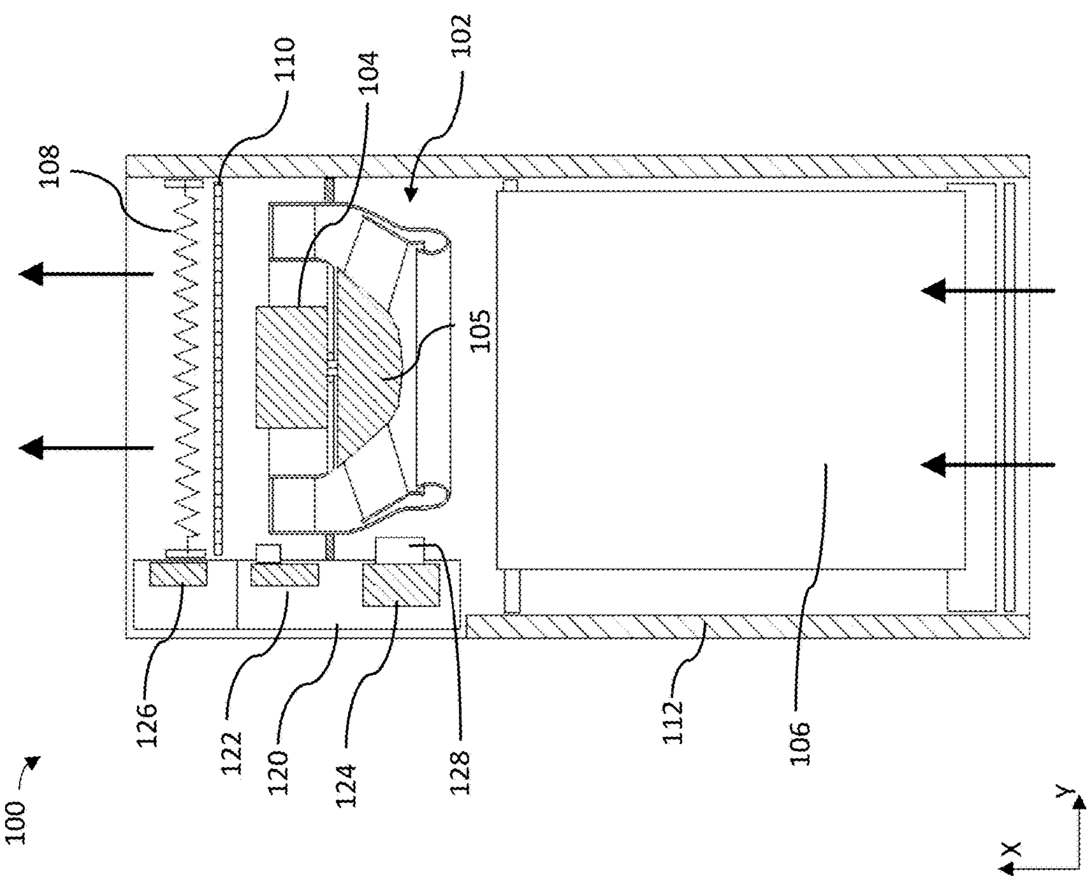
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FIG. 1A

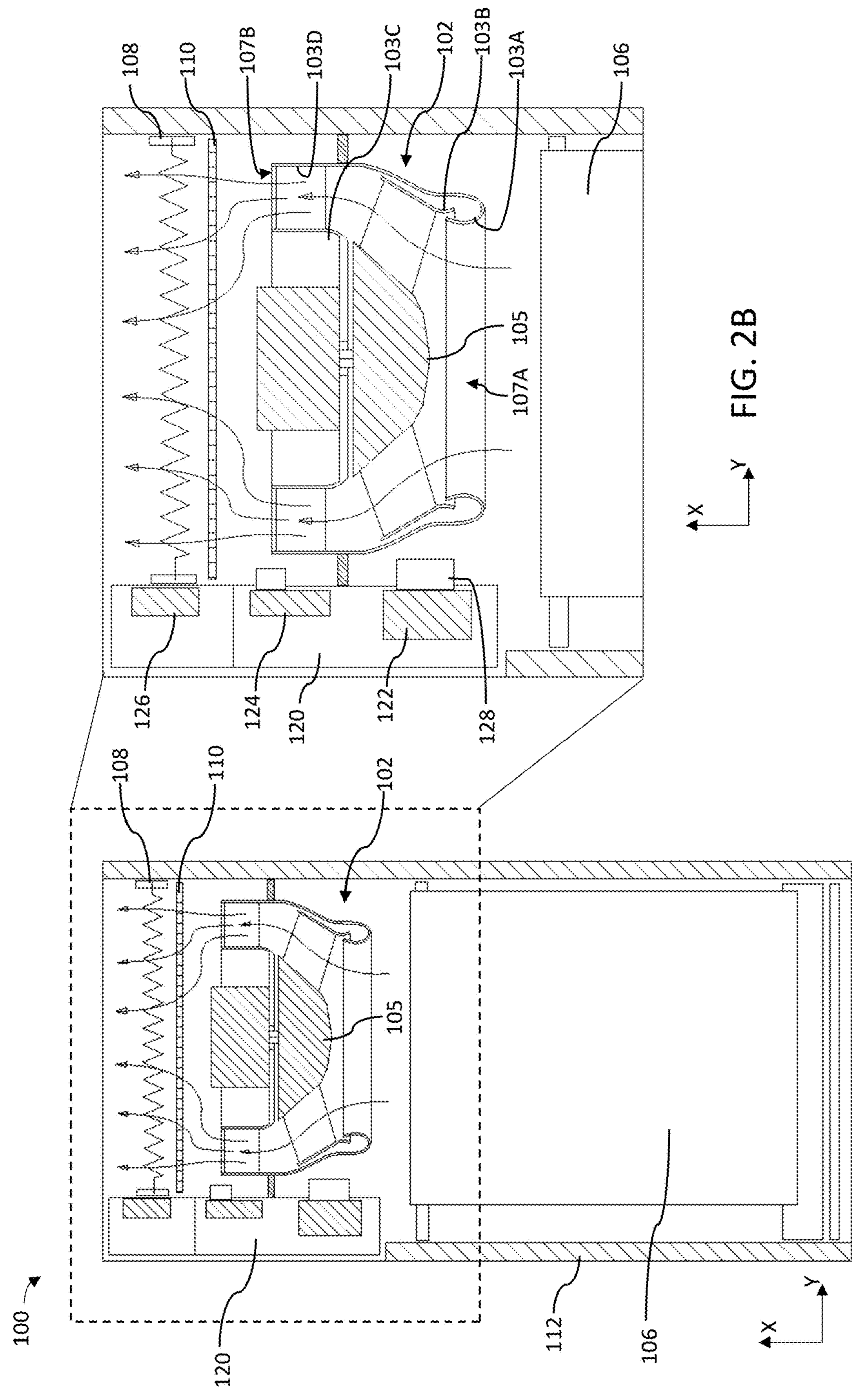
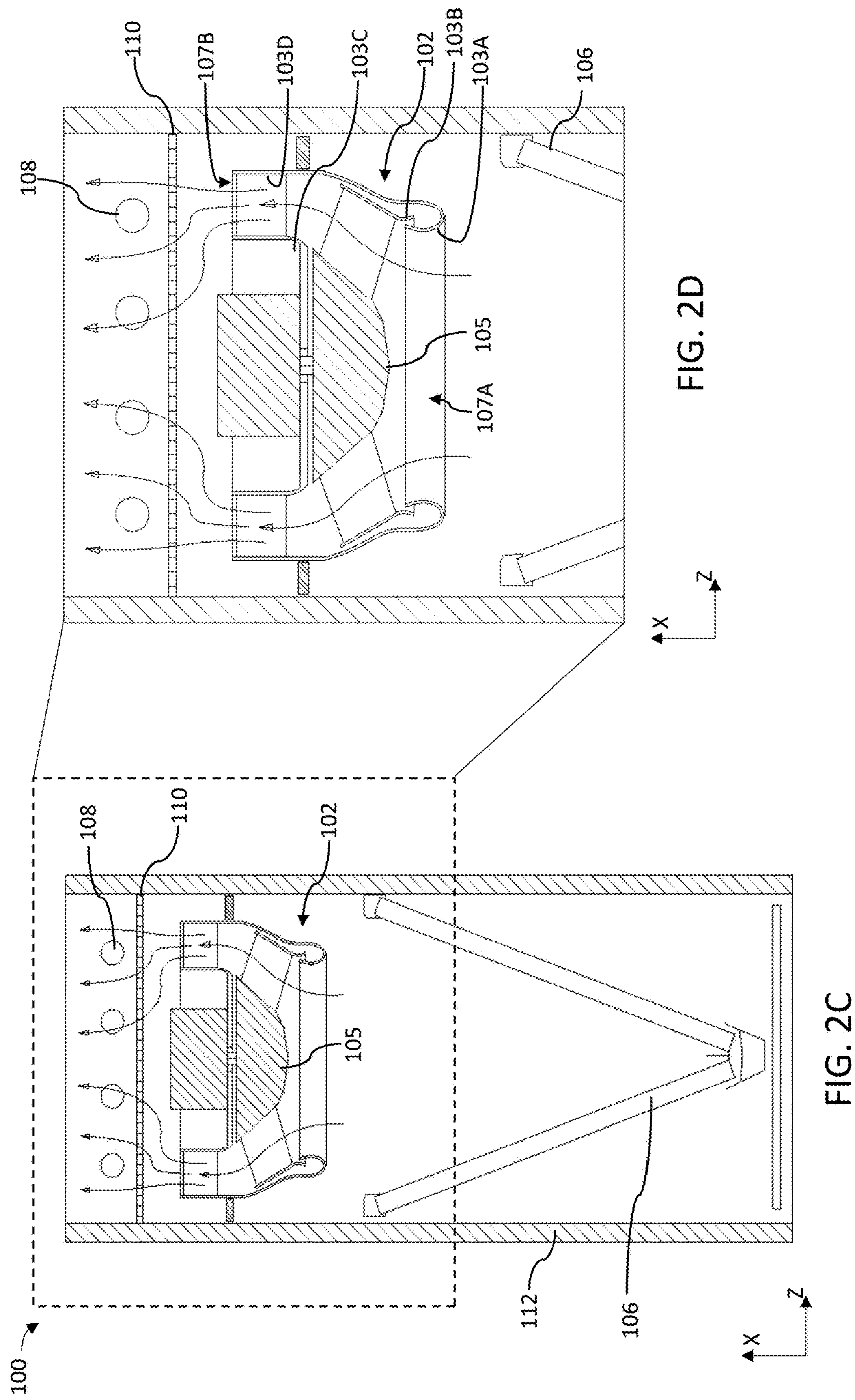

100
102
103A
103B
103C
103D
105
106
107A
107B
108
110
112
120
122
124
126
128
X
Y

FIG. 2A

FIG. 2B


110
107B
103D
103C
102
103B
103A
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108
105
107A
X
Z
100
108
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102
105
112
106
X
Z

FIG. 2D

FIG. 2C

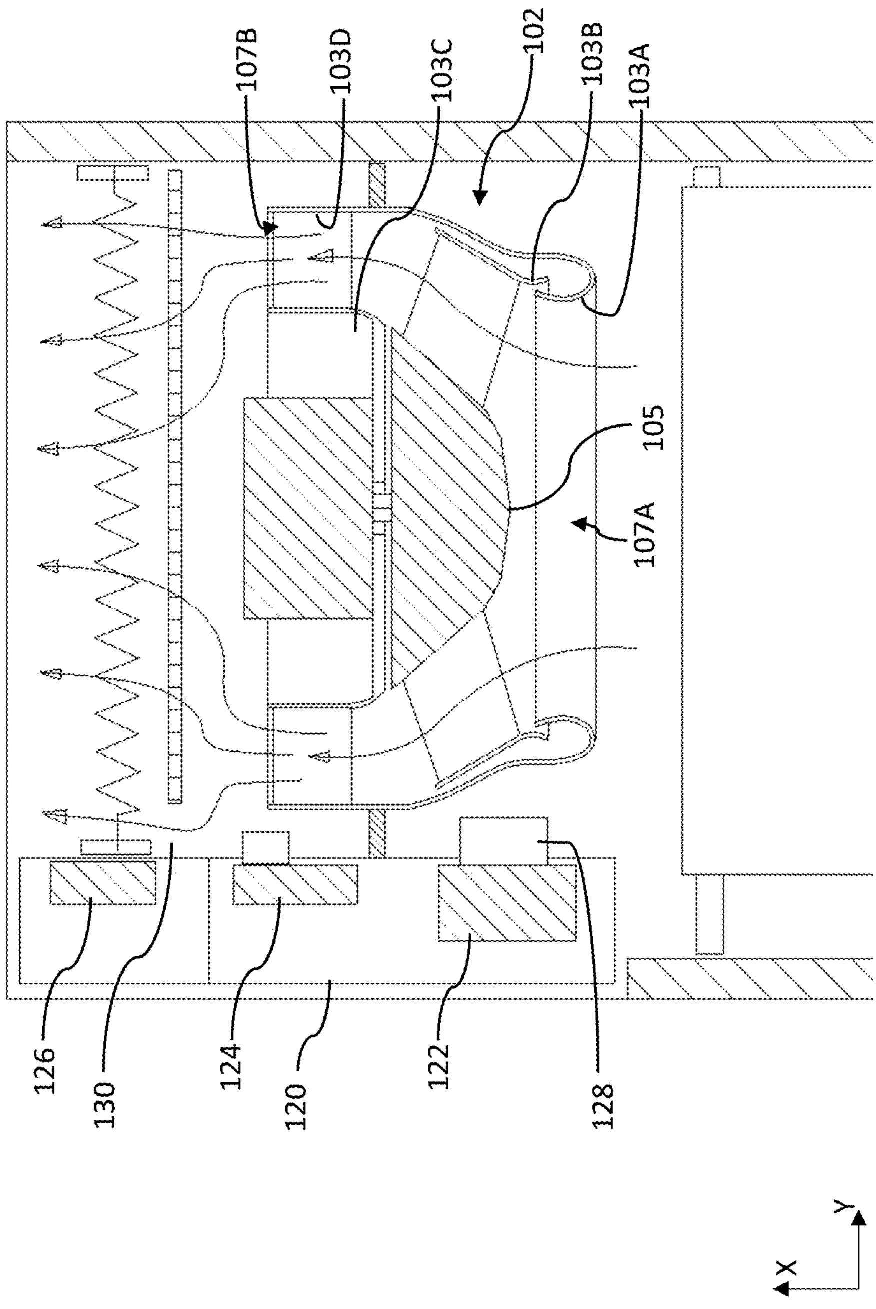
107B
103D
103C
102
103B
103A
105
107A
126
130
124
120
122
128
X
Y

FIG. 2E

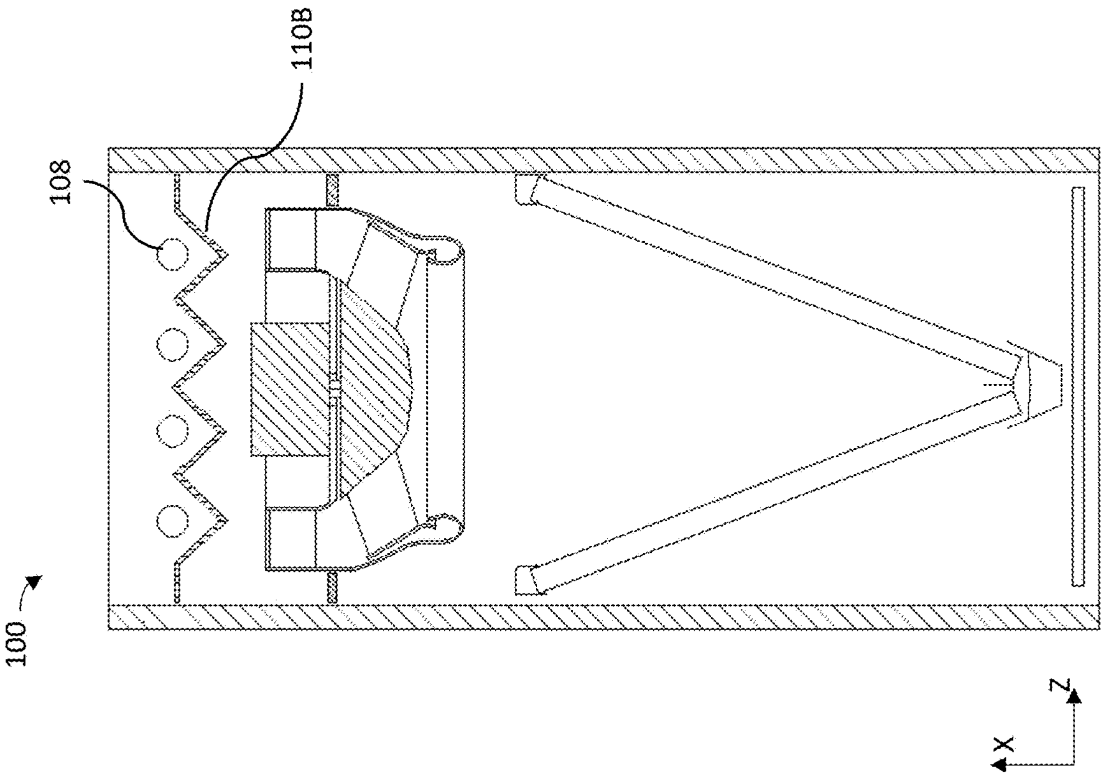

FIG. 3B

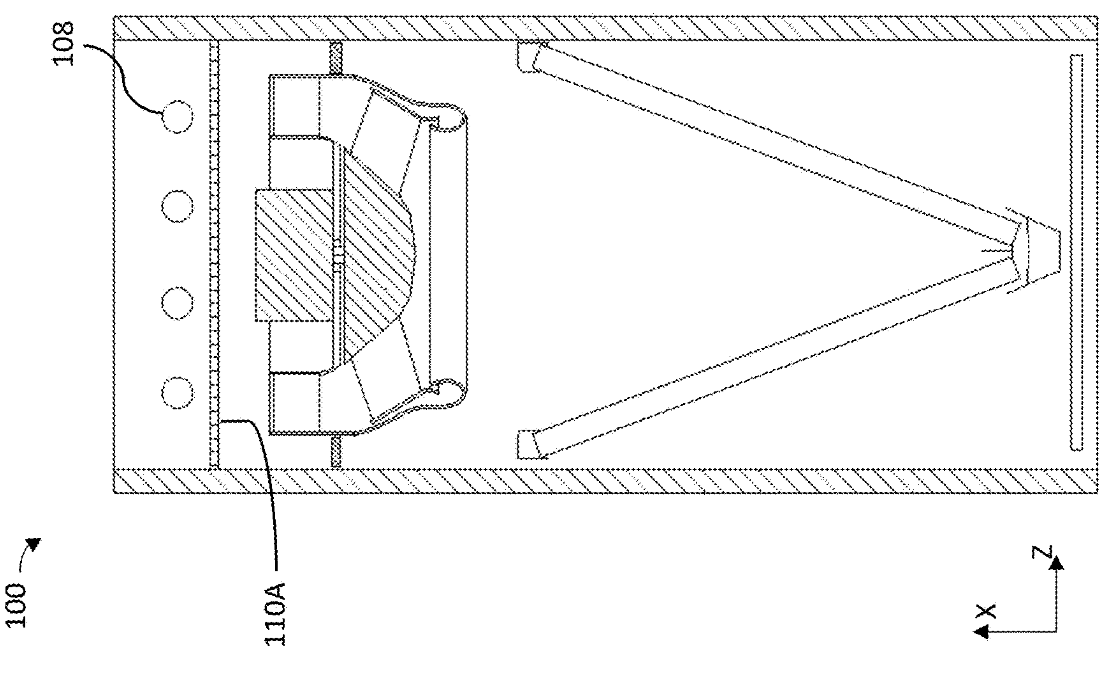

FIG. 3A

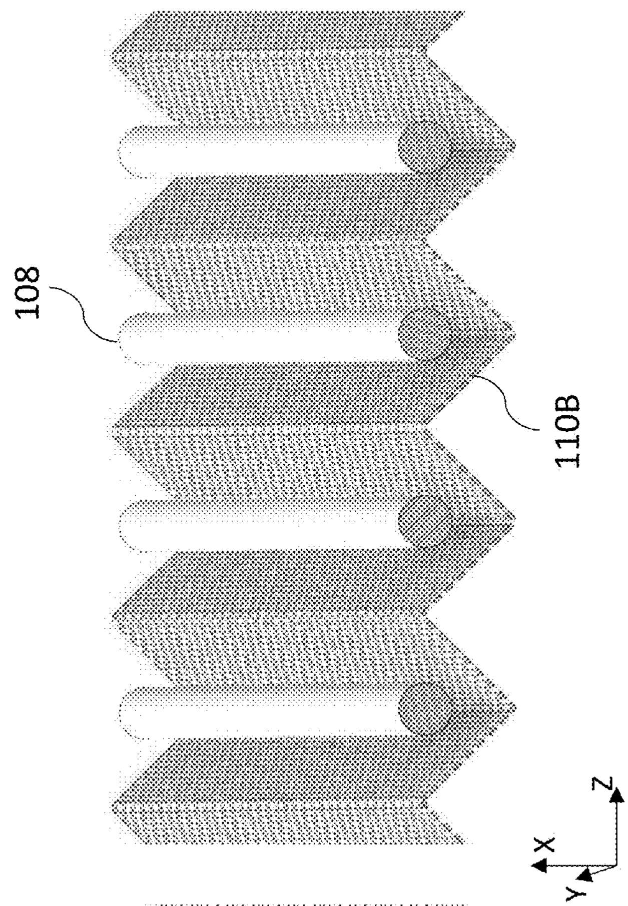

FIG. 4B

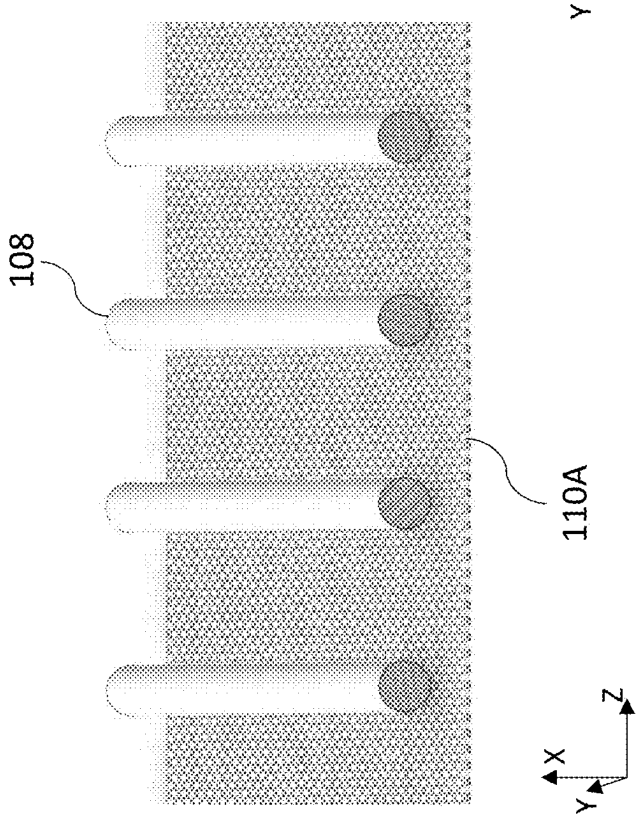

FIG. 4A

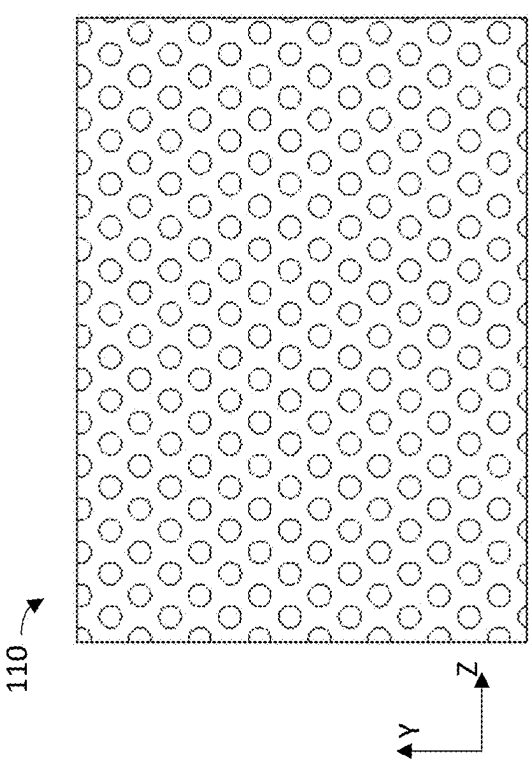

FIG. 5A

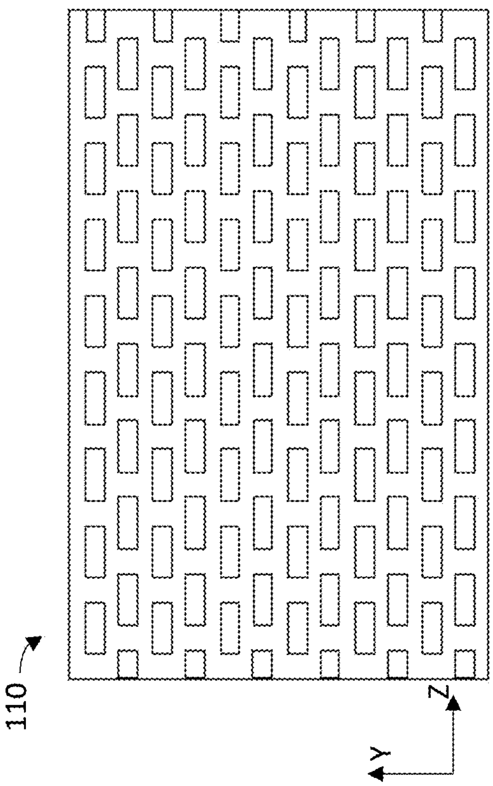

FIG. 5B

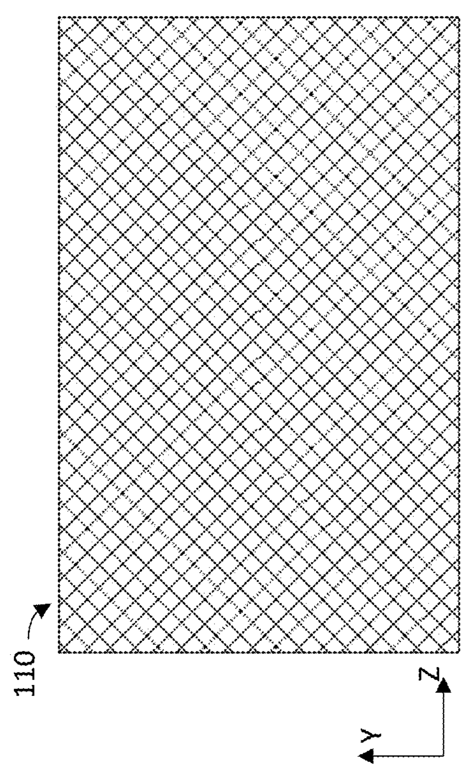

FIG. 5C

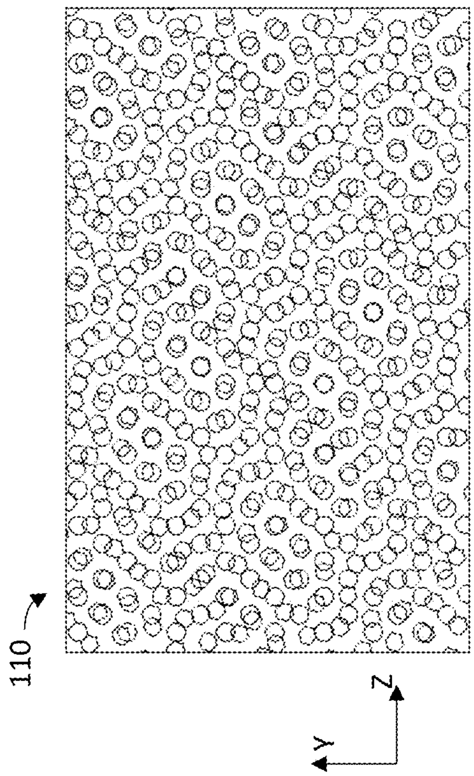

FIG. 5D

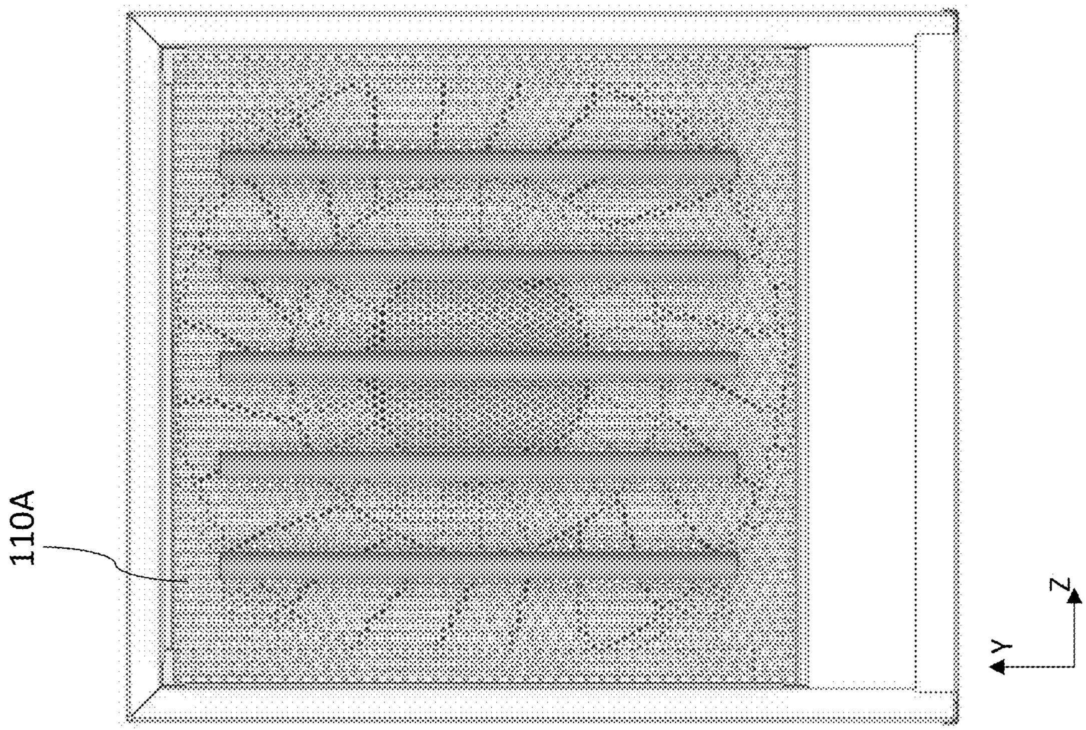

FIG. 6B

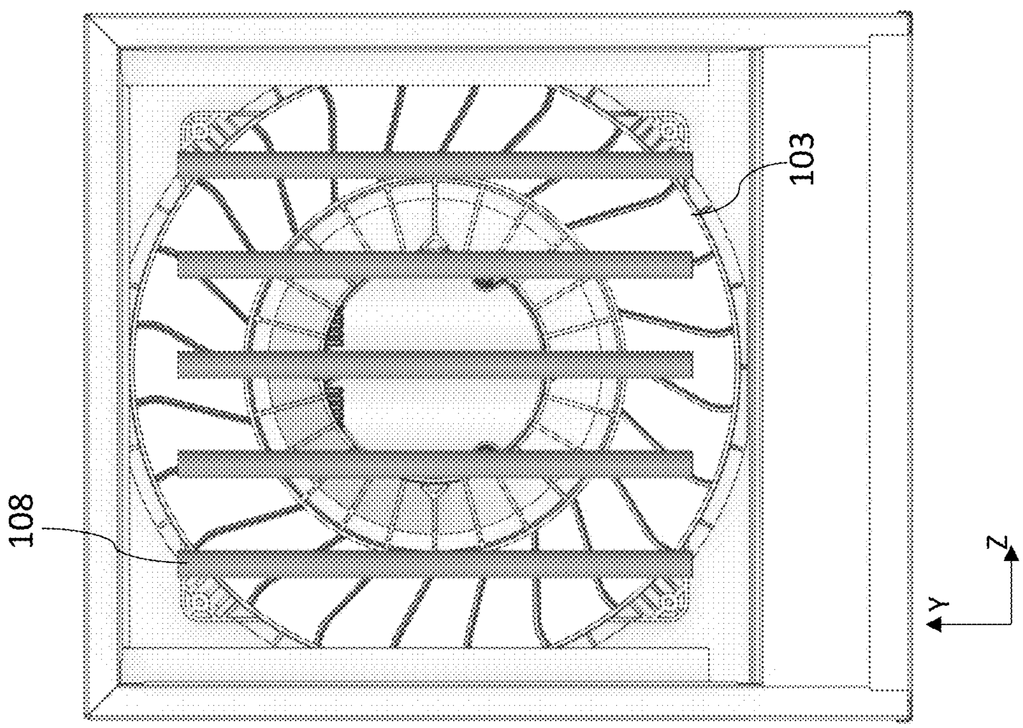

FIG. 6A

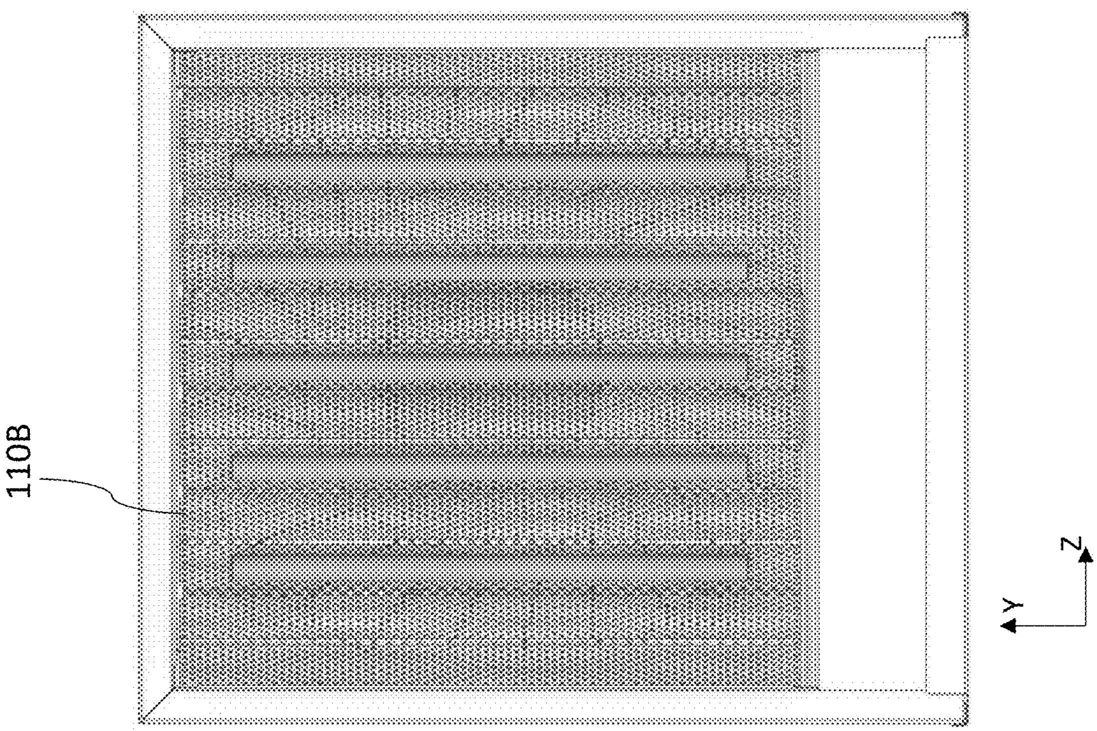

FIG. 6C

AIR HANDLING UNIT HAVING A HEAT SHIELD FLOW DISTRIBUTOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a Continuation-in-part of U.S. Non-provisional application Ser. No. 18/745,286 filed on Jun. 17, 2024, which claims the benefit of U.S. Provisional Patent Application No. 63/511,199, filed on Jun. 30, 2023, which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The subject disclosure relates to an air handling unit, and more particularly, to an air handling unit having a heat shield flow distributor.

BACKGROUND

[0003] Ducted residential air handling units (AHUs) for heating, ventilation and air conditioning (HVAC) typically include a primary refrigerant-to-air heat exchanger, a motor-driven blower, refrigerant piping and valves, electronic controls, and optional electric heat. The electric heat may be used as the only source for comfort heating in an air conditioning only system, or it may be used to supplement or coordinate with heat transfer from the primary heat exchanger for a system operating as a heat pump. Traditional systems utilize metallic components in the vicinity of the electric heat elements. In particular, these systems typically use metallic double-inlet forward-curved centrifugal blowers and the electric heat elements are placed in the blower discharge section. Thermal radiation exposure from the electric heat in these systems is compatible with the blower components. These traditional systems tend to be relatively large as a consequence of the blower configuration. Alternative AHUs may incorporate a mixed-flow fan, an axial-flow fan, or an in-line centrifugal fan in a more compact arrangement where the fan rotational axis is substantially parallel with the AHU longitudinal direction. These systems may utilize plastic fan components and may place the fan motor drive in the region of the fan discharge. In these alternative systems, the placement of electric heat at the fan discharge may over-heat the fan components, motor, and controls. Example systems of this type may include a solid heat shield. One example is described in U.S. Pat. No. 9,945,568B2 issued to Yokoyama et al., entitled “Air conditioning apparatus.” The applicants have found that variations beyond the above art can be made that improve the thermal management of fan, motor, and other components upstream of electric heat elements. These improvements have been developed and verified experimentally.

SUMMARY

[0004] Disclosed herein is an air handling unit (AHU) having a heat shield flow distributor. The AHU comprises a motor-driven fan with an annular outlet, and configured to move an airflow through a housing of the AHU, a primary heat exchanger configured to cool or heat the air moved through the AHU, one or more heat elements placed downstream of the motor-driven fan, the one or more heat elements being configured to transfer heat to the air moved by the motor-driven fan, and a heat shield placed between the motor-driven fan and the one or more heat elements, and configured to reduce heat transfer upstream and downstream of the heat shield and redistribute the airflow from the one or more heat elements in an upstream direction from of the heat shield, wherein the heat shield comprises a distribution of openings configured to allow air to flow through the heat shield.

[0005] In one or more embodiments, the primary heat exchanger comprises a refrigerant-to-air type heat exchanger positioned upstream of the motor-driven fan.

[0006] In one or more embodiments, the one or more heat elements comprises electrically powered resistance-type heaters implemented as any one or a combination of: coils, strips, ribbons, or combined ceramic/metallic construction.

[0007] In one or more embodiments, the heat shield is metallic.

[0008] In one or more embodiments, the heat shield is configured to fractionally block the radiated heat from the one or more heat elements, reflect the radiated heat, absorb the radiated heat, and/or transfer the absorbed heat to the airflow moving downstream from the motor-driven fan, by convection.

[0009] In one or more embodiments, the heat shield comprises at least one of: a smooth profile, a corrugated profile, a louvered profile, or a multiple-layer profile.

[0010] In one or more embodiments, the heat shield extends across an internal cross-sectional profile of the housing.

[0011] In one or more embodiments, the heat shield may be placed at a distance that is about 5% to about 25% of a fan exit diameter away from the annular outlet of the motor-driven fan.

[0012] In one or more embodiments, the distribution of openings is formed by at least one of, perforations, slots, louvers, offset-slits, or mesh.

[0013] In one or more embodiments, each opening of the distribution of openings has a diameter or opening length scale of about 2 mm to about 8 mm.

[0014] In one or more embodiments, a ratio of total open area to total surface area of the heat shield is between about 30% to about 65%.

[0015] In one or more embodiments, the distribution of openings is defined on the heat shield to redistribute the airflow from the motor-driven fan and prevent heated air back-flow from the one or more heat elements.

[0016] In one or more embodiments, openings of the distribution of openings are uniformly distributed on the heat shield.

[0017] In one or more embodiments, the AHU includes a fan motor power control module housed in a control box isolated from the airflow from the motor-driven fan.

[0018] In one or more embodiments, the control box includes one or more heat sinks protruding into the airflow, the one or more heat sinks being configured to dissipate heat from the fan motor power control module through the control box, and wherein the one or more heat sinks are placed upstream of the heat shield.

[0019] In one or more embodiments, the one or more heat elements are controlled by control electronics placed in a control box, and wherein heat generated by the control electronics is at least partially dissipated by the airflow flowing over an end wall of the control box.

[0020] In one or more embodiments, the heat generated by the control electronics is dissipated through the air redirected by the distribution of openings of the heat shield or by one or more slots in the heat shield adjacent to the control box.

[0021] In one or more embodiments, the motor-driven fan comprises any one of: a mixed-flow fan, an axial-flow fan, or a centrifugal fan with rotational axis parallel with a longitudinal direction of the AHU, and wherein the motor-driven fan is powered by a direct drive variable speed motor.

[0022] In one or more embodiments, the motor-driven fan comprises a mixed-flow fan comprising, a diagonal flow impeller comprising a plurality of blades extending from the diagonal flow impeller, and an axis of rotation of the diagonal flow impeller arranged in-line with a direction of the airflow through the housing, wherein an air flow path through the diagonal flow impeller has a mean angle that is oriented along a direction divergent from the axis of rotation, a fan inlet casing disposed circumferentially around a shroud wall of an impeller, defining a clearance between a fan inlet casing and a shroud wall, with upstream and downstream flow control clearances, and a set of axial outlet guide vanes disposed downstream of the impeller, comprising a plurality of vanes extending radially from a stator hub towards a stator shroud, and configured to redirect the airflow exiting the impeller such that the airflow exiting the outlet guide vanes is substantially parallel to the axis of rotation of the impeller, and a direct drive variable speed motor disposed in the stator hub used to power an impeller of the fan.

[0023] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, features, and techniques of the invention will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The accompanying drawings are included to provide a further understanding of the subject disclosure of this invention and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the subject disclosure and, together with the description, serve to explain the principles of the subject disclosure.

[0025] In the drawings, similar components and/or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label with a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

[0026] FIG. **1**A is a cross-sectional representation of a side view of an air handling unit (AHU), in accordance with one or more embodiments of the subject disclosure.

[0027] FIG. **1**B is a cross-sectional representation of an end or front view of the AHU, in accordance with one or more embodiments of the subject disclosure.

[0028] FIG. **2**A is a cross-sectional representation of the side of the AHU shown in FIG. **1**A, with paths of airflow through the AHU, in accordance with one or more embodiments of the subject disclosure.

[0029] FIG. **2**B is an enlarged representation of the airflow through the AHU of FIG. **2**A, in accordance with one or more embodiments of the subject disclosure.

[0030] FIG. **2**C is a cross-sectional representation of the end or front of the AHU, with paths of the airflow through the AHU, in accordance with one or more embodiments of the subject disclosure.

[0031] FIG. **2**D is an enlarged representation of the airflow through the AHU of FIG. **2**C, in accordance with one or more embodiments of the subject disclosure.

[0032] FIG. **2**E is an enlarged representation of a slot on the AHU through which at least a portion of the airflow passes, in accordance with one or more embodiments of the subject disclosure.

[0033] FIG. **3**A is a cross-sectional representation of the AHU having a planar heat shield, in accordance with one or more embodiments of the subject disclosure.

[0034] FIG. **3**B is a cross-sectional representation of the AHU having a corrugated heat shield, in accordance with one or more embodiments of the subject disclosure.

[0035] FIG. **4**A is an isometric view of one or more heat elements of the AHU placed over a planar heat shield, in accordance with one or more embodiments of the subject disclosure.

[0036] FIG. **4**B is an isometric view of the heat elements of the AHU placed over a corrugated heat shield, in accordance with one or more embodiments of the subject disclosure.

[0037] FIGS. **5**A to **5**D are representations of distribution of openings defined on the heat shield, in accordance with one or more embodiments of the subject disclosure.

[0038] FIGS. **6**A to **6**C are top view representations of different heat shields blocking a line of sight from the heat elements to a motor-driven fan of the AHU, in accordance with one or more embodiments of the subject disclosure.

DETAILED DESCRIPTION

[0039] The following is a detailed description of embodiments of the disclosure depicted in the accompanying drawings. The embodiments are in such detail as to clearly communicate the disclosure. However, the amount of detail offered is not intended to limit the anticipated variations of embodiments; on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the subject disclosure as defined by the appended claims.

[0040] Various terms are used herein. To the extent a term used in a claim is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in printed publications and issued patents at the time of filing.

[0041] In the specification, reference may be made to the spatial relationships between various components and to the spatial orientation of various aspects of components as the devices are depicted in the attached drawings. However, as will be recognized by those skilled in the art after a complete reading of the subject disclosure, the components of this invention described herein may be positioned in any desired orientation. Thus, the use of terms such as “above,” “below,” “upper,” “lower,” “first,” “second,” or other like terms to describe a spatial relationship between various components or to describe the spatial orientation of aspects of such components should be understood to describe a relative relationship between the components or a spatial orientation of aspects of such components.

[0042] As used herein, "substantially" means largely or considerably, but not necessarily wholly, or sufficiently to work for the intended purpose. The term "substantially" thus allows for minor, insignificant variations from an absolute or perfect state, dimension, measurement, result, or the like as would be expected by a person of ordinary skill in the art, but that do not appreciably affect overall performance.

[0043] The use of the term "about" with reference to a numerical value includes ±10% of the numerical value.

[0044] Ducted residential heating, ventilation, and air conditioning (HVAC) systems utilize an air handling unit (AHU) with optional electrically powered heat elements for comfort heating of the air delivered by the AHU. However, such heat elements also radiate heat towards internal components of the AHU, such as fans/blowers, motors, control modules/circuitry, and the like, potentially causing them to overheat. Overheating such AHU components can lead to inefficiencies and/or risk of damage. These problems are exacerbated in compact, ducted fan coil AHUs where components are placed in close proximity to the heat elements. While some solutions use solid heat shields to protect the AHU components from the heat generated by the heat elements, such heat shields block/impede the flow/redistribution of air through the AHU, thereby leading to inefficiencies.

[0045] The subject disclosure solves these problems by providing an AHU with a heat shield having a distribution of openings. The openings allow the air to pass through and be redistributed, while solid portions of the heat shield block radiation, absorb radiation, convect heat to the air stream, and/or reflect radiated energy.

[0046] Referring to FIGS. **1**A and **1**B, cross-sectional representations of a side and an end/front view of an air handling unit (AHU) **100** are shown, respectively. The AHU **100** may include a fan **102**, a motor **104**, and a primary heat exchanger **106**, which may be placed/disposed within a housing duct or a housing **112**. The fan **102** (when driven by the motor **104**) may be configured to move air through the housing **112**. The primary heat exchanger **106** may be configured to cool or heat the air being moved. The AHU **100** may further include one or more heat elements **108** configured to transfer heat to the airflow. The primary heat exchanger **106** may be placed upstream of the fan **102**, and the heat elements **108** may be placed downstream of the fan **102**, with respect to the direction in which the air is being moved. To prevent the heat from the heat elements **108** from transferring or propagating to the fan **102** (and other components upstream of the heat elements **108**), the AHU **100** may include a heat shield **110**. The heat shield **110** may be disposed between the fan **102** and the heat elements **108**.

[0047] Further, the AHU **100** may include a control box **120** configured to accommodate electrical control modules such as an AHU control module **122**, a fan motor power control module **124**, and/or a heat control module **126**. The fan motor power control module **124** and the heat control module **126** may be configured to control the motor **104**, and the heat elements **108**, respectively, and the AHU control module **122** may be configured to control the overall operation of the AHU **100**.

[0048] In one or more embodiments, the fan **102** may be configured to move air through the housing **112** of the AHU **100**. The fan **102** may be configured to move air in a direction along a longitudinal axis of the housing **112** (such as along X axis with respect to FIGS. **1**A to **3**B). Solid arrows in FIGS. **1**A and **1**B represent the air entering and exiting the housing **112**. As applied, the AHU housing **112** is nominally connected to return and supply air ducts at the housing inlet and exit, respectively. The main flow through the housing **112** moves in the X direction with respect to FIGS. **1**A to **3**B), and the fan rotational axis is substantially parallel with the longitudinal axis of the housing **112**.

[0049] In one or more embodiments, the fan **102** may include any one of a mixed-flow fan/diagonal-flow fan, an axial-flow fan, or a centrifugal fan with rotational axis parallel with a longitudinal direction of the AHU **100**. The mixed-flow fan **102** may include a diagonal flow impeller **105** having a plurality of blades extending from the diagonal flow impeller **105**, and an axis of rotation of the diagonal flow impeller **105** being arranged in-line with a direction of the airflow through the housing **112**.

[0050] An air flow path (as shown in FIGS. **2**A to **2**E) through the impeller **105** may be inclined. In one or more embodiments, the air flow path may have a mean angle that is oriented along a direction divergent from the axis of rotation of the impeller **105**. The fan **102** may have a fan inlet having a substantially circular shape, and a fan outlet **107**B (as shown in FIGS. **2**B and **2**D) having a substantially annular shape.

[0051] The impeller **105** may be driven by a direct-drive motor, such as the motor **104**. The direct drive variable speed motor (such as the motor **104**) disposed in the stator hub **103**C is used to drive the impeller **105** of the fan **102**.

[0052] The mixed-flow fan also includes a fan inlet casing **103**A disposed circumferentially around a shroud wall **103**B of the diagonal flow impeller **105** of the fan **102**. The fan inlet casing **103**A and the shroud wall **103**B may define a fan inlet **107**A (as shown in FIGS. **2**B, **2**D, and **2**E). Further, a clearance or a gap may be defined between the fan inlet casing **103**A and the shroud wall **103**B, with upstream and downstream flow control clearances, which may allow for upstream and downstream flow control clearances.

[0053] Further, in one or more embodiments, the fan **102** may include a set of outlet guide vanes (not shown) disposed downstream of the impeller **105**. The outlet guide vanes may extend radially from a wall of the stator hub **103**C towards a stator shroud wall **103**D. The guide vanes may be configured to redirect the airflow exiting the impeller **105** such that the airflow exiting the outlet guide vanes is substantially parallel to the axis of rotation of the impeller **105**. Such designs of the fan **102** may allow the spatial footprint of the AHU **100** in at least one dimension (such as along the longitudinal axis) to be reduced. Consequently, various components of the AHU **100** may be placed in proximity to each other, including the heat element **108**.

[0054] In one or more embodiments, the housing **112** may have a substantially rectangular cross-sectional profile. In other embodiments, the housing **112** may have a substantially cylindrical cross-sectional profile.

[0055] The fan **102** may be driven by the motor **104**. As stated, the motor **104** may be a direct-drive motor. The motor **104** may be operable with a continuous speed control. The motor **104** may be communicably coupled to HVAC controls of the air conditioning unit, or the AHU control module **122**.

[0056] The motor **104** may have a shaft rotationally locked to the impeller hub/impeller **105** of the fan **102**, to allow the motor **104** to drive the fan **102**.

[0057] In one or more embodiments, the primary heat exchanger **106** may be disposed within the housing **112** of the AHU **100**, and positioned along the direction of airflow upstream of the fan **102**. In one or more embodiments, the heat exchanger **106** may be configured to facilitate heat transfer to and from the air moving through the housing **112**. In some embodiments, the heat exchanger **106** may be configured to cool the air moving through the housing **112**. In some other embodiments, the heat exchanger **106** may be configured to heat the air moving through the housing **112**.

[0058] In one or more embodiments, the primary heat exchanger **106** includes a refrigerant-to-air heat type exchanger. In such embodiments, the primary heat exchanger **106** may include tubing through which a heat exchanging fluid or a refrigerant may be flowed.

[0059] The tubing may be routed within one or more heat exchanger slabs. In one or more embodiments, the primary heat exchanger **106** may include two slabs in a substantially V-shaped arrangement, as shown in FIGS. **1**B, **2**C, **3**A and **3**B. In other embodiments, the slabs may be arranged substantially A-shaped. In further embodiments, the primary heat exchanger **106** may be a single slab heat exchanger.

[0060] In one or more embodiments, the primary heat exchanger **106** may be a microchannel heat exchanger. In one or more embodiments, the primary heat exchanger may be a round-tube plate-fin heat exchanger.

[0061] In one or more embodiments, the heat elements **108** may be configured to generate heat, and transfer the heat to the airflow. The heat elements **108** may be configured to supplement the heating of the airflow, i.e., in addition to the heating provided by the primary heat exchanger **106**, and thereby allow for improved temperature regulation of the airflow. The heat elements **108** may be placed downstream of the fan **102**, such that the airflow moved by the fan **102** may be heated by the heat elements **108**, before the airflow exits the housing **112**.

[0062] In one or more embodiments, the heat elements **108** may be electrically powered resistance-type devices implemented as at least one of, coils, strips, ribbons, and/or combined ceramic/metallic construction. In one or more embodiments, the heat elements **108** may extend between at least two walls of the housing **112**. In some embodiments, the coils may extend substantially parallel along a plane (such as a plane perpendicular to the longitudinal axis, or a plane formed on by Y and Z axes). Multiple rows of parallel coils may be arranged downstream of the heat shield **110**. In other embodiments, heat element coils may be arranged in a concentric circular pattern.

[0063] In one or more embodiments, the heat elements **108** may be configured to radiate energy/heat in all directions, including upstream and downstream of the heat elements **108**, and also towards the walls of the housing **112**. Consequently, the heat from the heat elements **108** may be transferred to the fan **102**, the motor **104**, the control box **120**, and other components of the AHU **100** upstream from the heat elements **108**. Such component heating may be undesirable due to its potential to introduce inefficiencies in the operation of, and risk damage to, such components. The AHU **100** may include the heat shield **110** to block or reduce heat transfer from the heat elements **108** to components upstream of the heat shield **110**.

[0064] In one or more embodiments, the heat shield **110** may be a perforated metallic plate disposed between the fan **102** and the heat elements **108**. In one or more embodiments, the heat shield **110** may extend substantially across an internal cross-sectional profile of the housing **112**. In such embodiments, the heat shield **110** may be oriented substantially perpendicular to the direction of the airflow, i.e., perpendicular to the longitudinal axis (or the X axis).

[0065] In one or more embodiments, the heat shield **110** may be configured to partially block thermal radiation heat transfer from the heat elements **108** to the components upstream of the heat shield **110**. Further, the heat shield **110** may also be configured to redistribute the airflow passing therethrough so that the velocity profile becomes more uniform.

[0066] In one or more embodiments, the heat shield **110** may be metallic in construction. For instance, the heat shield **110** may be made of steel or aluminum. The material construction of the heat shield **110** may be configured to withstand the high temperature environment in the vicinity of the heat elements **108**.

[0067] In one or more embodiments, the heat shield **110** may be configured to fractionally block the heat/radiated energy/heat (from the heat elements **108**), reflect the radiated energy/heat, absorb the radiated energy/heat, and/or transfer the absorbed energy to the airflow moving downstream from the fan **102** by convection. In one or more embodiments, the heat shield **110** may include a distribution of openings (such as those shown in FIGS. **5**A to **5**D) defined therein. In one or more embodiments, the openings may be formed by cavities or holes cut out from a solid plate making the heat shield **110**.

[0068] In other embodiments, the heat shield **110** may be a mesh construction (i.e., woven wire or screen) or made from a set of louvers (which may be arranged or stacked).

[0069] The open cross-sectional area of the perforated plate, mesh, or louvers may be configured to allow the airflow to pass therethrough. In one or more embodiments, the size and shape of the openings may also be adapted to block direct line-of-sight for heat being radiated from the heat elements **108** (as shown in FIGS. **6**A to **6**C), thereby preventing the heat from propagating to the components upstream of the heat shield **110**.

[0070] The openings may also be sized, shaped, and/or defined in patterns that facilitate the airflow from the fan **102** to be redistributed when passing through the heat shield **110**, i.e., modify the airflow distribution profile downstream of the heat shield **110** so that it becomes more uniform.

[0071] In one or more embodiments, the heat shield **110** may be placed at a distance from the fan **102**. The distance may be selected to enable the airflow to be distributed as it passes through the heat shield **110**. In one or more embodiments, the heat shield **110** may be at a distance of about 5% to about 25% of a fan exit diameter away from the annular outlet **103**B of the motor-driven fan **102**.

[0072] Various designs of the heat shield **110** are provided in FIGS. **3**A to **5**D, and the ability of the heat shield **110** to block line-of-sight is illustrated in FIGS. **6**A to **6**C. However, it may be appreciated by those skilled in the art that the heat shield **110** may be implemented with other designs adapted to requirements and/or constraints of the use case, and may not be limited to those shown in the FIGS. **3**A to **6**C.

[0073] Referring to FIGS. **2**A to **2**D, representations of airflow streamlines are shown. FIG. **2**A provides a representation of the side view of the AHU **100**, and FIG. **2**B shows an enlarged representation thereof, showing airflow streamlines. Similarly, FIG. **2**C provides a representation of the front/end view of the AHU **100**, and FIG. **2**D represents an enlarged representation thereof, also showing airflow streamlines.

[0074] In one or more embodiments, the fan **102** may be disposed within the housing **112**, to move airflow from an inlet to an outlet of the AHU **100**/housing **112**, as indicated in FIGS. **1**A and **1**B using arrows. The fan **102** may be configured to draw air upstream thereof, on being driven by the motor **104** through the fan inlet **107**A, which may create a negative pressure upstream of the fan **102**. The negative pressure may cause the air to be drawn into the housing **112**, either from ambient environment or from other ducts connected to the housing **112**. The primary heat exchanger **106**, being disposed between the inlet and the fan **102**, may exchange heat as the air is moved through housing **112**.

[0075] The fan **102** may draw the air into the fan inlet **107**A, and move the air along the airflow path defined therein. The airflow path within the fan impeller **105** may be inclined with respect to the longitudinal direction.

[0076] Further, the fan **102** may discharge the air downstream of the fan **102** through the fan outlet **107**B, as shown by arrows in FIGS. **2**A to **2**D. The fan **102** may be configured to move the air out from the housing **112** through the outlet of the AHU **100**. The heat elements **108**, being placed between the outlet and the fan **102**, may heat the air passing therethrough. The airflow between the inlet and the outlet of the AHU **100** may be substantially parallel to the longitudinal axis (i.e., along X axis) of the housing **112**.

[0077] As stated, the openings of the heat shield may be shaped and/or sized to redistribute (or change distribution) of the airflow passing through and moving downstream of the heat shield **110**. As shown, while the fan outlet **107**B may have a substantially annular profile, the openings of the heat shield **110** may cause the distribution of the airflow to change. The size and shape of the openings may be adjusted to obtain the desired airflow distribution. In one or more embodiments, the openings may be arranged to redistribute the air to be substantially uniform along a cross-sectional area of the AHU **100**.

[0078] Referring to FIG. **2**E, another enlarged representation of the AHU **100** is shown. The control box **120** may be configured to house/accommodate the AHU control module **122**, the fan motor power control module **124**, and the heat control module **126**, which may be electronic circuits configured to control the operation of the AHU **100**. In one or more embodiments, the control box **120** may be isolated from the housing **112** through-flow moved by the fan **102**.

[0079] In one or more embodiments, the fan motor power control module **124** may be configured to control the motor **104**, i.e., start-up, shut-down, speed control, and the like. The fan motor power control module **124** may transmit control signals to the motor **104**, or modulate the amount of electrical power supplied thereto for controlling the motor **104**. In one or more embodiments, the heat control module **126** may be configured to control the amount of heat generated by the heat elements **108**. The heat control module **126** may control the heat elements **108** by modulating the electrical power supplied thereto.

[0080] In one or more embodiments, the AHU control module **122** includes a packaged rooftop air management system that is communicably coupled to the different components of the AHU **100**, including, without limitations, the heat exchanger **106**, the heat elements **108**, the fan **102**, and the motor **104**. The AHU control module **122** may be implemented as a controller configured to control operations of the different components of the AHU **100**. Accordingly, the AHU control module **122** may be a master controller, configured to control the fan motor power control module **124** and the heat control module **126** through transmission of electronic signals. In some embodiments, the AHU control module **122** may be a part of the HVAC controls of the air conditioning system.

[0081] As stated, the heat radiated from the heat elements **108** may transfer in all directions, including towards the control box **120**. Further, heat may also be generated as a result of the operation of the modules within the control box **120**. In such cases, the modules within the control box **120** may also heat up, which may cause inefficiencies and/or risk of damage thereto.

[0082] In one or more embodiments, corresponding heat sinks (such as heat sink **128**) may be disposed/attached to the AHU control module **122**, the fan motor power control module **124**, and/or heat control modules **126**. The heat sinks may be configured to at least partially dissipate heat into the airflow.

[0083] In one or more embodiments, the heat sinks may be implemented as blocks extending from the corresponding modules. In other embodiments, the heat sinks may include fins through which the heat from the modules may be rejected.

[0084] In one or more embodiments, the heat sinks may be made of aluminum. In other embodiments, the heat sinks may be made of any thermally conductive material, which facilitates heat dissipation from the modules within the control box **120** to the airflow.

[0085] In one or more embodiments, the heat sinks may be positioned to extend into the airflow path within the housing **112**. The heat sinks may be configured to dissipate heat from the corresponding modules within the control box **120**. In one or more embodiments, the heat sinks may be placed upstream of the heat shield **110**. The heat sinks may be configured to dissipate heat to the airflow upstream of the heat shield **110**, as shown in FIG. **2**E.

[0086] In one or more embodiments, the heat generated by the control electronics is dissipated through the air redirected by the distribution of openings of the heat shield or by one or more slots in the heat shield adjacent to the control box.

[0087] In one or more embodiments, the slots (such as slot **130**) may be defined between the control box **120** and the heat shield **110**. The slot **130** may be adjacent to the control box **120**, to allow at least a portion of the airflow to flow along an end wall of the slot **130**. The airflow may absorb heat from the control box **120** when passing through the slot **130**. In such embodiments, the slot **130** may allow the heat in the modules within the control box **120** to be dissipated to the airflow passing through the slot **130**.

[0088] The shape of the heat shield **110** may be adapted based on the requirements for the use case. In one or more embodiments, the heat shield **110**A may have a substantially planar contour as shown in FIGS. **3**A and **4**A. In such embodiments, the planar heat shield **110**A may be defined as a planar perforated plate extending along the Y-Z plane. Further, FIG. **4**A shows the heat elements **108** placed downstream of the planar heat shield **110**A. The heat elements **108** may be uniformly arranged over the planar heat shield **110**A.

[0089] In other embodiments, heat shield **110**B may include a substantially corrugated profile, as shown in FIGS. **3**B and **4**B. The corrugated profile of the heat shield **110**B may provide surface area that is larger than a surface area of the planar heat shield **110**A of similar dimensions. In one or more embodiments, the heat elements **108** may be placed between two peaks of the corrugated heat shield **110**B, at the downstream side thereof, as shown in FIG. **4**B. In one or more embodiments, the corrugated profile may also improve blocking of heat radiation due to the angled surfaces. Furthermore, the corrugations may channel the airflow to aid in a more controlled redistribution of air.

[0090] In further embodiments, the heat shield **110** may include a louvered profile. In such embodiments, multiple louvers/slats may be stacked or arranged in a parallel or overlapping manner. Gaps formed between the louvers allow for airflow passage, while the solid portions of the louvers block direct radiation. The angle of the louvers and the gaps therebetween may be adjusted to control the direction of airflow and to optimize the blocking of heat radiation.

[0091] In one or more embodiments, the heat shield **110** may include a multiple-layer profile. In such embodiments, different types of the heat shield **110** may be stacked or arranged together to form the multiple-layer profile. The multiple layer profile may provide flexibility to combine and obtain the benefits of multiple heat shields within a single AHU. In other embodiments, multiple layers of the heat shield **110** may also allow the air to be redistributed differently, based on the requirements and/or constraints of the use case.

[0092] FIGS. **5**A to **5**D are representations of distribution of openings defined on the heat shield **110**. In one or more embodiments, the distribution of openings is formed by at least one of, perforations, slots, louvers, offset-slits, and/or mesh, but not limited thereto.

[0093] In one or more embodiments, the openings may be circular, as shown in FIG. **5**A. The openings may be uniformly distributed, and in a staggered arrangement. In other embodiments, the openings may be rectangular, as shown in FIG. **5**B. The rectangular openings may be arranged in horizontal rows, with each row being offset with respect to adjacent rows in a staggered arrangement. In further embodiments, the openings may be formed by a mesh, as shown in FIG. **5**C. The mesh may define diamond shaped openings formed by multiple wire elements arranged in an interleaving arrangement. In still further embodiments, the openings may be irregularly shaped, as shown in FIG. **5**D. The irregularly shaped openings may be randomly distributed across the heat shield **110**.

[0094] In one or more embodiments, a ratio of total open area to total surface area of the heat shield **110** may be between about 30% to about 65%. The open area range allows for a trade-off between airflow performance and thermal management.

[0095] In one or more embodiments, each opening in the distribution of openings may have a diameter or opening length scale of about 2 mm to about 8 mm. The number of openings may be adjusted to achieve the aforementioned total opening area. The range of opening sizes may provide a balance between allowing sufficient airflow through the heat shield **110** and effectively blocking heat radiation. In one or more embodiments, the size of the openings of the distribution may be heterogenous, such as in embodiment shown in FIG. **5**D.

[0096] In one or more embodiments, the distribution of openings may be defined on the heat shield **110** to redistribute the airflow from the motor-driven fan **102** and prevent heated air back-flow from the one or more heat elements **108**. The openings, due to their size, shape, and distribution, may modify the airflow profile exiting the fan **102**.

[0097] Referring to FIGS. **6**A to **6**C, top view representations of different heat shields **110** blocking a line of sight from the heat elements **108** to the motor-driven fan **102** of the AHU **100** are shown

[0098] Referring to FIG. **6**A, a top view of an AHU **100** without the heat shield **110** is shown. In FIG. **6**A, the heat elements **108** are visible and positioned downstream of the fan **102** (i.e., fan outlet **107**B). As shown, there is a direct line of sight from the heat elements **108** to the fan **102**. The direct line of sight means that radiated heat from the heat elements **108** may directly impinge upon the fan **102** and components upstream thereof, potentially causing overheating.

[0099] Referring to FIG. **6**B, a top view of an AHU **100** with the planar heat shield **110**A is shown. In FIG. **6**B, the heat shield **110** is disposed between the heat elements **108** and the fan **102**. As shown, the heat shield **110** obstructs the direct line of sight from the heat elements **108** to the fan **102**. Even though the heat shield **110** includes openings, the arrangement and size of openings and solid portions of the heat shield **110** are such that a direct, unimpeded path for heat radiation from the heat elements **108** to the fan **102** is blocked. The solid portions of the heat shield **110** interrupt the line of sight, thereby preventing direct heat radiation from reaching the fan **102**.

[0100] Referring to FIG. **6**C, a top view of an AHU **100** with a corrugated heat shield **110**B is shown. Similar to FIG. **6**B, in FIG. **6**C, the corrugated heat shield **110**B is disposed between the heat elements **108** and the fan **102**. As shown, the corrugated heat shield **110**B also obstructs the direct line of sight from the heat elements **108** to the fan **102**. The corrugated profile of the heat shield **110**B, with alternating peaks and troughs thereof, further enhances the blockage of line of sight. The corrugated profile of the heat shield **110**B may also promote scattering and reflection of heat radiation, in addition to blocking the direct path/line-of-sight.

[0101] Thus, the heat shield **110**, with distribution of openings, may provide effective thermal protection to sensitive components of the AHU **100**, such as the fan **102** and electronics within the control box **120**, from the heat radiated by the heat elements **108**. The heat shield **110** may reduce or eliminate overheating issues, improve efficiency, and enhance reliability of the AHU **100**, particularly in compact designs where components are placed in close proximity to each other. The ability of the heat shield **110** to redistribute airflow, in addition to blocking radiated heat, provides further advantages in optimizing the performance of the AHU **100**.

[0102] While the subject disclosure has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention as defined by the appended claims. Modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed, but that the invention includes all embodiments falling within the scope of the invention as defined by the appended claims.

[0103] In interpreting the specification, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced. Where the specification claims refer to at least one of something selected from the group consisting of A, B, C . . . and N, the text should be interpreted as requiring only one element from the group, not A plus N, or B plus N, etc.

1. An air handling unit (AHU) comprising:
- a motor-driven fan with an annular outlet configured to move an airflow through a housing of the AHU;
- a primary heat exchanger configured to cool or heat air moved through the AHU;
- one or more heat elements placed downstream of the motor-driven fan, the one or more heat elements being configured to transfer heat to the airflow; and
- a heat shield placed between the motor-driven fan and the one or more heat elements, and configured to reduce heat transfer from the one or more heat elements in an upstream direction of the heat shield and redistribute the airflow upstream and downstream of the heat shield, wherein the heat shield comprises a distribution of openings configured to allow air to flow through the heat shield.

2. The AHU of claim **1**, wherein the primary heat exchanger comprises a refrigerant-to-air type heat exchanger positioned upstream of the motor-driven fan.

3. The AHU of claim **1**, wherein the one or more heat elements comprise electrically powered resistance-type heaters implemented as at least one of: coils, strips, ribbons, and/or combined ceramic/metallic construction.

4. The AHU of claim **1**, wherein the heat shield is metallic.

5. The AHU of claim **1**, wherein the heat shield is configured to fractionally block the radiated heat from the one or more heat elements, reflect the radiated heat, absorb the radiated heat, and/or transfer the absorbed heat to the airflow moving downstream from the motor-driven fan.

6. The AHU of claim **1**, wherein the heat shield comprises at least one of: a smooth profile, a corrugated profile, a louvered profile, and a multiple-layer profile.

7. The AHU of claim **1**, wherein the heat shield extends across an internal cross-sectional profile of the housing.

8. The AHU of claim **1**, wherein the heat shield is placed at a distance that is about 5% to about 25% of a fan exit diameter away from the annular outlet of the motor-driven fan.

9. The AHU of claim **1**, wherein the distribution of openings is formed by at least one of: perforations, slots, louvers, offset-slits, and/or mesh.

10. The AHU of claim **1**, wherein each opening of the distribution of openings comprises a diameter or opening length scale of about 2 mm to about 8 mm.

11. The AHU of claim **1**, wherein a ratio of total open area to total surface area of the heat shield is between about 30% to about 65%.

12. The AHU of claim **1**, wherein the distribution of openings is defined on the heat shield to redistribute the airflow from the motor-driven fan and prevent heated air back-flow from the one or more heat elements.

13. The AHU of claim **1**, wherein openings of the distribution of openings are uniformly distributed on the heat shield.

14. The AHU of claim **1**, further comprising a fan motor power control module housed in a control box isolated from the airflow moved by the motor-driven fan.

15. The AHU of claim **14**, wherein the control box comprises one or more heat sinks protruding into the airflow, the one or more heat sinks being configured to dissipate heat from the fan motor power control module through the control box, and wherein the one or more heat sinks are placed upstream of the heat shield.

16. The AHU of claim **1**, wherein the one or more heat elements are controlled by control electronics placed in a control box, and wherein heat generated by the control electronics is at least partially dissipated by the airflow flowing over an end wall of the control box.

17. The AHU of claim **16**, wherein heat generated by the control electronics is dissipated through the airflow redirected by the distribution of openings of the heat shield or by one or more slots in the heat shield adjacent to the control box.

18. The AHU of claim **1**, wherein the motor-driven fan comprises any one of: a mixed-flow fan, an axial-flow fan, or a centrifugal fan with rotational axis parallel with a longitudinal direction of the AHU, and wherein the motor-driven fan is powered by a direct drive variable speed motor.

19. The AHU of claim **1**, wherein the motor-driven fan is a mixed-flow fan comprising:
- a diagonal flow impeller comprising a plurality of blades extending from the diagonal flow impeller, and an axis of rotation of the diagonal flow impeller being arranged in-line with a direction of the airflow through the housing, wherein an air flow path through the diagonal flow impeller has a mean angle that is oriented along a direction divergent from the axis of rotation;
- a fan inlet casing disposed circumferentially around a shroud wall of the diagonal flow impeller, defining a clearance between the fan inlet casing and the shroud wall, with upstream and downstream flow control clearances;
- a set of axial outlet guide vanes disposed downstream of the diagonal flow impeller, comprising a plurality of vanes extending radially from a stator hub towards a stator shroud, and configured to redirect the airflow exiting the diagonal flow impeller such that the airflow exiting the outlet guide vanes is substantially parallel to the axis of rotation of the diagonal flow impeller; and
- a direct drive variable speed motor disposed in the stator hub to drive the diagonal flow impeller of the motor-driven fan.

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