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(54) **SYSTEMS AND METHODS TO MODERATE AIRFLOW**

(57) A system and method to moderate an airflow in a heating, ventilation, and air conditioning (HVAC) unit (10), including an evaporator portion (18) disposed in a housing (14), the evaporator portion including at least one blower (26) disposed within a plenum (25) in airflow communication with a first heat exchanger (24), the plenum including at least one plenum wall, a vortex control device (27) operably coupled to the at least one plenum wall.

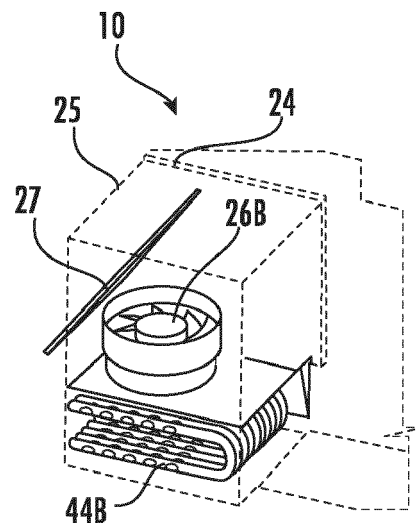


FIG. 3A

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Description

[0001] The subject matter disclosed herein relates to residential and commercial air conditioning products. More specifically, the present disclosure relates to supply air fan systems for heating, ventilation, and air conditioning (HVAC) units.

[0002] An HVAC unit typically includes a refrigeration circuit having a compressor, condenser and evaporator in fluid communication with each other and circulating a working fluid such as refrigerant or other cooling medium therethrough. The components are typically located in a housing, through which fresh air and/or return air from a conditioned space is circulated and a supply airflow of a selected temperature is output to the conditioned space. Such products are typically installed on a roof of a building, but may also be installed at other locations, such as on the ground.

[0003] In some systems, the flow of supply air is powered through the HVAC unit by a fan that is either housed, or unhoused. For example, plenum fans are fans without housings that discharge freely into a plenum or cabinet space and discharge air in all directions rather than having flow directed as with a housed fan. A supply air fan or impeller (wheel) can be described by the blade constructions, and may include forward-curved fans, airfoil fans, and vane axial fans.

[0004] During operation of the fan, such as a vane axial fan, an airflow is drawn into the fan from a heat exchanger (e.g., evaporator, condenser), and the plenum is negatively pressurized as airflow is directed to a space to be conditioned. This operation may cause a standing airflow vortex to form in the plenum. When this occurs, the vortex can be ingested by the fan leading to fan blade passage tones that negatively impact perceived sound quality and overall sound levels.

[0005] Some have sought to address this problem by positioning a device such as a filter, in front of a fan to filter out flow unsteadiness, by breaking up turbulent large vortical structures down to the size of the filter width. However, such devices require an interaction with the main airflow stream entering the fan, which can typically impede airflow. Impeded air flow can result in pressure losses associated with flow filtering and lead to diminished fan performance.

[0006] What is needed then, is a system and method for preventing the formation of the vortical structures to improve sound quality and overall sound levels of the fan without negatively affecting fan performance.

[0007] According to a first aspect of the invention there is provided a heating, ventilation, and air conditioning (HVAC) unit, including, an evaporator portion disposed in a housing, the evaporator portion including: a first heat exchanger; at least one blower disposed within a plenum in airflow communication with the first heat exchanger, the plenum including at least one plenum wall; and a vortex control device operably coupled to the at least one plenum wall.

[0008] Optionally, the at least one blower includes a fan disposed within a fan shroud and rotatable around a fan hub.

[0009] Optionally, the vortex control device includes a thickness dimension that is equal to or greater than 0.01 inches (0.03 cm) and equal to or less than 2.0 inches (5 cm).

[0010] Optionally, the vortex control device includes a length dimension that is equal to or greater than 0.25 times and equal to or less than 1.5 times, the height of the at least one plenum wall.

[0011] Optionally, the vortex control device includes a width dimension that is equal to or greater than 0.5 times the diameter of the fan hub and equal to or less than 3.0 times the diameter of the fan shroud.

[0012] Optionally, the vortex control device includes a flat plate having a perforated surface.

[0013] Optionally, the vortex control device extends outwardly from the at least one plenum wall by a straight angle equal to or greater than 5 degrees and less than or equal to 75 degrees.

[0014] Optionally, the vortex control device includes a plate having an arcuate shape and a perforated surface.

[0015] Optionally, the vortex control device extends outwardly from the at least one plenum wall, at an arc angle equal to or greater than 5 degrees and equal to or less than 75 degrees.

[0016] According to another aspect of the invention, there is provided a method for controlling an airflow in a heating, ventilation, and air conditioning (HVAC) unit including: a first heat exchanger, at least one blower disposed within a plenum in airflow communication with the first heat exchanger, wherein the at least one blower is disposed in a fan shroud and rotatable around a fan hub; and a vortex control device, the method including: attaching the vortex control device to at least one plenum wall; and operating the fan to direct an airflow into the housing.

[0017] Optionally, the at least one blower includes a fan.

[0018] Optionally, the method further includes, configuring the vortex control device to have a thickness dimension that is equal to or greater than 0.01 inches (0.03 cm) and equal to or less than 2.0 inches (5 cm).

[0019] Optionally, the method further includes, configuring the vortex control device to have a length dimension that is equal to or greater than 0.25 times and equal to or less than 1.5 times, the height of the at least one plenum wall.

[0020] Optionally, the method further includes, configuring the vortex control device to have a width dimension that is equal to or greater than 0.5 times the diameter of the fan hub and equal to or less than 3.0 times the diameter of the fan shroud.

[0021] Optionally, the method further includes, configuring the vortex control device as a flat plate having a perforated surface.

[0022] Optionally, the method further includes, configuring the vortex control device to extend outwardly from

the at least one plenum wall by a straight angle equal to or greater than 5 degrees and less than or equal to 75 degrees.

[0023] Optionally, the method further includes, configuring the vortex control device as a plate having an arcuate shape and a perforated surface.

[0024] Optionally, the method further includes, configuring the vortex control device to extend outwardly from the at least one plenum wall, at an arc angle equal to or greater than 5 degrees and equal to or less than 75 degrees.

[0025] The subject matter is particularly pointed out and distinctly claimed at the conclusion of the specification. The foregoing and other features, and advantages of the present disclosure are apparent from certain exemplary embodiments described in the following detailed description taken, by way of example only, in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic illustration of a HVAC unit.

FIG. 2A is a perspective view of a portion of a HVAC unit.

FIG. 2B is a side view of portion of a HVAC unit.

FIG. 3A is a perspective view of a portion of a HVAC unit.

FIG. 3B is a side view of a portion of a HVAC unit.

FIG. 4A is a perspective view of a portion of a HVAC unit.

FIG. 4B is a top view of a portion of a HVAC unit.

FIG. 5A is a perspective view of a portion of a HVAC unit.

FIG. 5B is a side view of a portion of a HVAC unit.

FIG. 6 is a perspective view of a portion of a HVAC unit.

FIG. 7 illustrates method for controlling an airflow in a HVAC unit.

[0026] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

[0027] As will be described in greater detail below the present disclosure provides for a system and method for controlling an airflow in an HVAC unit. It should be evident however to one skilled in the art that the present disclosure is not limited to the specific examples given and could be utilized in other systems where it may be desirable to control an HVAC airflow.

[0028] Shown in FIG. 1 is an HVAC unit 10. HVAC unit 10 is configured to be mounted, for example, on a rooftop or alternatively on the ground next to a building. The HVAC unit 10 is generally contained in a housing 14 and includes a condenser portion 16 and an evaporator portion 18. The condenser portion 16 includes a compressor 20 for increasing the pressure of a working fluid (e.g., refrigerant) and directing the working fluid to a condenser 22 located in the condenser portion 16.

[0029] The condenser portion 16 includes a condenser portion inlet 36 and a condenser portion outlet 38. A con-

denser fan 40 directs an outside airflow 42 into the condenser portion inlet 38, across the condenser 22 and out of the condenser portion outlet 36 to reject heat from the condenser 22.

[0030] The evaporator portion 18 includes a first heat exchanger (e.g., evaporator) 24, and a plenum 25 having at least one wall, each adjacent to at least one blower 26. The plenum 25 includes at least one operably coupled vortex control device 27. The at least one blower 26 provides for movement of a supply airflow 28 which may be returned from a conditioned space 30 across the first heat exchanger 24, through which the refrigerant flows, to cool the supply airflow 28. The supply airflow 28 is then directed to the conditioned space 30 via an outlet 32 and a supply duct 34.

[0031] The at least one blower 26 may have an upper portion and a lower portion (not shown). The upper portion allows for the intake of supply airflow 28. The lower portion allows the supply airflow 28 to exit the at least one blower 26 continuing along the supply airflow pathway 46. In some embodiments, the HVAC unit 10 includes a section downstream of the at least one blower 26, which includes a gas-fired heat exchanger 44, or alternatively a heating coil or an electric resistance heater, located in a supply airflow pathway 46 between the at least one blower 26 and the outlet 32. Thus, the HVAC unit 10 can operate in either a cooling mode or a heating mode. When operating in cooling mode, the supply airflow 28 is cooled by flowing across the first heat exchanger 24. When operating in heating mode, the gas-fired heat exchanger 44 is activated to heat the supply airflow 28 downstream of the at least one blower 26.

[0032] When the HVAC unit 10 is operational, the supply airflow 28 enters the plenum 25 and is drawn into the at least one blower 26. If the plenum 25 does not also have at least one vortex control device 27, the supply airflow 28 may form at least one standing vortex during blower 26 operation. If a standing vortex forms, it may become anchored on at least one inner wall of plenum 25. In this example, as the blower 26 draws in supply airflow 28, it may also ingest at least one standing vortex which may cause blade passage tones that can negatively impact perceived sound quality and increase the sound overall levels of the HVAC unit 10. The cycle of forming and ingesting at least one standing vortex may result in a persistent unwanted tone emanating from the HVAC unit 10. However, a supply airflow 28 pathway may be affected by operably coupling at least one vortex control device 27 to at least one plenum 25 wall, thereby reducing or preventing the incidence of standing vortex(ices) formation and improving overall tonal quality and reducing overall noise levels.

[0033] FIGS. 2A, 3A, 4A, 5A and 6 provide embodiments of a portion of HVAC unit 10 in accordance with embodiments of the disclosure. FIGS. 2B, 3B, 4B, and 5B provide alternate views of a portion of HVAC unit 10 in accordance with embodiments of the disclosure.

[0034] Referring to FIG. 2A, HVAC unit 10 has a first

heat exchanger 24, such as an evaporator, a plenum 25, at least one vortex control device 27, at least one blower FIG. 2B, 26 such as a fan (e.g., vane axial fan), and a supply airflow 28A, 28B. Also shown is an optional gas-fired heat exchanger 44 downstream of the supply airflow 28. In one non-limiting embodiment, the at least one blower 26 is a fan disposed within a fan shroud FIG. 2B, 26A and rotatable around a fan hub FIG. 3A, 26B. In an alternate embodiment, the HVAC unit may have at least two blowers 26 and at least two vortex control devices 27, as illustrated in FIG. 6.

[0035] The vortex control device 27 may be integral with or operably coupled to at least one plenum 25 wall. By way of example, vortex control device 27 may be manufactured to be integral with and extend from, at least one plenum 25 wall by a manufacturing process, including casting, molding, machining, welding, joining, forming, or additive manufacturing. Alternatively, vortex control device 27 may be operably coupled to at least one plenum 25 wall by at least one of a fastener and a support device. Alternatively, vortex control device 27 may be operably coupled to at least one plenum 25 wall by a joining, securing or interlocking mechanism that may prevent the vortex control device from separating, detaching or dislodging from the plenum 25 wall.

[0036] In one non-limiting embodiment, the vortex control device 27 may have a perforated surface. A perforated surface allows airflow through the vortex control device which prevents excessive pressure losses that would otherwise negatively impact blower 26 aerodynamic performance.

[0037] The vortex control device 27 may have any shape (flat or arcuate) and any dimension (thickness, length, width), and may be coupled to a plenum 25 wall at any angle that prevents the formation of a standing vortex(ices) and without also negatively impacting aerodynamic performance or efficiency of HVAC unit 10. For example, the vortex control device 27 may have a substantially flat shape, as illustrated in FIG. 2B. In one non-limiting embodiment, the vortex control device 27 may extend outwardly from at least one plenum 25 wall at an angle equal to or greater than 5 degrees and less than or equal to 75 degrees.

[0038] In another non-limiting embodiment, the vortex control device 27 may have an arcuate shape, as illustrated in FIG. 5A and FIG. 5B. In one non-limiting embodiment, the vortex control device 27 may extend outwardly from at least one plenum 25 wall at an arc angle that may be equal to or greater than 5 degrees and equal to or less than 75 degrees. The vortex control device 27 can also have, concave, convex, triangular, semi cylindrical, or semi-spherical shape.

[0039] In one non-limiting embodiment, the vortex control device 27 may have a thickness dimension that is equal to or greater than 0.01 inches (0.03 cm) and equal to or less than 2.0 inches (5 cm).

[0040] The height of the vortex control device 27 may be related to the diameter of the fan shroud (D_{FS}). (See,

FIG. 5B) Referring to FIG. 2B, the height of the vortex control device 27 may be determined from the foundation (e.g., fan deck) to which the blower 26 and/or fan shroud 26A may be attached, to a vertical distance (H_1) that extends to the topmost point of the vortex control device 27. H_1 may be equal to or greater than $0.5D_{FS}$ and less than or equal to $5.0D_{FS}$. Alternatively, the height (H_2) of the vortex control device 27 may be determined in relation to the height of the fan shroud 26A and H_1 . In this example, the height (H_2) of the vortex control device 27 may be determined from the foundation (e.g., fan deck) to which the blower 26 and/or fan shroud 26A may be attached, to a vertical distance (H_2) that extends to the topmost point of the fan shroud 26A. H_2 may be equal to or greater than $0.5(H_1)$ and less than or equal to $1.5(H_1)$. If the vortex control device is attached to the fan deck, H_2 may be equal to or greater than $0.0(H_1)$ and less than or equal to $1.5(H_1)$.

[0041] In another non-limiting embodiment, the vortex control device 27 may have a length (L) dimension that may be determined in relation to the H_1 . L may be equal to or greater than $0.25(H_1)$ and less than or equal to $1.5(H_1)$.

[0042] In another non-limiting embodiment, the vortex control device 27 may have a width dimension that may be determined in relation to the diameter (D_{FS}) of the fan shroud 26A. W may be equal to $3D_{FS}$ or less. Alternatively, W may be determined in relation to the diameter (D_{FH}) fan hub 26B (not shown). In this example, W may be equal to or greater than $0.5D_{FH}$.

[0043] The position of the vortex control device 27 in the plenum 25 may vary. For example, FIG. 2A shows a vortex control device 27 positioned between two parallel walls of the plenum 25. In this example, the first heat exchanger 24 is on a side opposing the vortex control device 27. FIG. 2B illustrates a side view of the vortex control device shown in FIG. 2A from the perspective of one side of the first heat exchanger 44A. In another non-limiting example, FIG. 3A shows a vortex control device 27 positioned adjacent to the first heat exchanger 24. FIG. 3B illustrates the position of the vortex control device 27 from another side of the first heat exchanger 44B.

[0044] In yet another non-limiting example, FIG. 4A shows a vortex control device 27 positioned between plenum wall 25 that is generally adjacent to evaporator 24 and plenum wall 25 that is opposite evaporator 24. FIG. 4B provides a top-down view of the vortex control device 27 from a position located above the blower 26.

[0045] As discussed above, the HVAC unit may have at least two blowers 26 and at least two vortex control devices 27, as illustrated in FIG. 6. The location, dimension and orientation of each vortex control device 27 is the generally the same as disclosed above.

[0046] Referring to FIG. 7, a method 700 for controlling an airflow in an HVAC unit 10 is disclosed. The HVAC unit 10 including a first heat exchanger 24 (e.g., an evaporator) at least one blower 26 disposed within a plenum 25 in airflow communication with the first heat exchanger

24, wherein the at least one blower 26 is disposed in a fan shroud 26A and rotatable around a fan hub 26B; and a vortex control device 27, the method including: attaching the vortex control device 27 to at least one plenum wall 25; and operating the blower 26 to direct an airflow into the housing 14.

[0047] In an operational HVAC unit 10, a supply airflow 28 is directed through the first heat exchanger 24 into an adjacent plenum 25 where it may interact with at least one vortex control device 27 that serves to prevent the formation of a standing vortex in the plenum 25. The blower 26 which is also adjacent to the first heat exchanger 24 within plenum 25. The method may include at least one or more blowers 26 and one or more vortex control device(s) 27 in the plenum 25.

[0048] The first step of the method 702 begins with attaching a vortex control device 27 to at least one plenum 25 wall. As discussed above, the vortex control device 27 may be integral with or operably coupled to at least one plenum 25 wall. In step 702, as supply airflow 28 enters the plenum 25 and interacts with at least one the vortex control device 27, which serves to prevent the formation of a standing vortex in the plenum, as discussed above.

[0049] At step 702, the method includes attaching a vortex control device 27 which may include a plate having at least one of a flat shape or an arcuate shape, and a perforated surface. The attached vortex control device 27 may be of any dimension (thickness, length, width), or may be of any shape or size, as discussed above. The vortex control device 27 may be operably coupled to at least one plenum wall and extend outwardly therefrom at a straight angle or an arcuate angle, as discussed above.

[0050] While the present invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the present invention is not limited to such disclosed embodiments. Additionally, while various embodiments have been described, it is to be understood that aspects of the present disclosure may include only some of the described embodiments. Accordingly, the present invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. A heating, ventilation, and air conditioning (HVAC) unit (10), comprising:

an evaporator portion (18) disposed in a housing (14), the evaporator portion comprising: a first heat exchanger (24);

at least one blower (26) disposed within a plenum (25) in airflow communication with the first heat exchanger, the plenum comprising at least one plenum wall; and

a vortex control device (27) operably coupled to the at least one plenum wall.

2. The HVAC unit of claim 1, wherein the at least one blower (26) comprises a fan disposed within a fan shroud (26A) and rotatable around a fan hub (26B).

3. The HVAC unit of claim 1 or 2, wherein the vortex control device (27) comprises a thickness dimension that is equal to or greater than 0.01 inches (0.03 cm) and equal to or less than 2.0 inches (5 cm).

4. The HVAC unit of any preceding claim, wherein the vortex control device (27) comprises a length dimension that is equal to or greater than 0.25 times and equal to or less than 1.5 times, the height of the at least one plenum (25) wall.

5. The HVAC unit of claim 2, or of claim 3 or 4 when dependent on claim 2, wherein the vortex control device (27) comprises a width dimension that is equal to or greater than 0.5 times the diameter of the fan hub (26B) and equal to or less than 3.0 times the diameter of the fan shroud (26A).

6. The HVAC unit of any preceding claim, wherein the vortex control device (27) comprises a flat plate having a perforated surface; preferably wherein the vortex control device (27) extends outwardly from the at least one plenum (25) wall by a straight angle equal to or greater than 5 degrees and less than or equal to 75 degrees.

7. The HVAC unit of any of claims 1-5, wherein the vortex control device (27) comprises a plate having an arcuate shape and a perforated surface; preferably wherein the vortex control device (27) extends outwardly from the at least one plenum (25) wall, at an arc angle equal to or greater than 5 degrees and equal to or less than 75 degrees.

8. A method (700) for controlling an airflow in a heating, ventilation, and air conditioning (HVAC) unit (10) comprising at least one blower (26) disposed within a plenum (25) in airflow communication with a first heat exchanger (24), wherein the at least one blower is disposed in a fan shroud (26A) and rotatable around a fan hub (26B), the method comprising:

attaching (702) a vortex control device (27) to at least one plenum wall; and
operating (704) the blower to direct an airflow into the housing (14).

9. The method of claim 8, wherein the at least one blower (26) comprises a fan.

10. The method of claim 8 or 9 further comprising, con-

figuring the vortex control device (27) to have a thickness dimension that is equal to or greater than 0.01 inches (0.03 cm) and equal to or less than 2.0 inches (5 cm).

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11. The method of any of claims 8-10 further comprising, configuring the vortex control device (27) to have a length dimension that is equal to or greater than 0.25 times and equal to or less than 1.5 times, the height of the at least one plenum (25) wall. 10
12. The method of any of claims 8-11 further comprising, configuring the vortex control device (27) to have a width dimension that is equal to or greater than 0.5 times the diameter of the fan hub (26B) and equal to or less than 2.0 times the diameter of the fan shroud (26A). 15
13. The method of any of claims 8-12 further comprising, configuring the vortex control device (27) as a flat plate having a perforated surface. 20
14. The method of any of claims 8-13 further comprising, configuring the vortex control device (27) to extend outwardly from the at least one plenum (25) wall by a straight angle equal to or greater than 5 degrees and less than or equal to 75 degrees. 25
15. The method of any of claims 8-14 further comprising, configuring the vortex control device (27) as a plate having an arcuate shape and a perforated surface; preferably further comprising, configuring the vortex control device (27) to extend outwardly from the at least one plenum (25) wall, at an arc angle equal to or greater than 5 degrees and equal to or less than 75 degrees. 30 35

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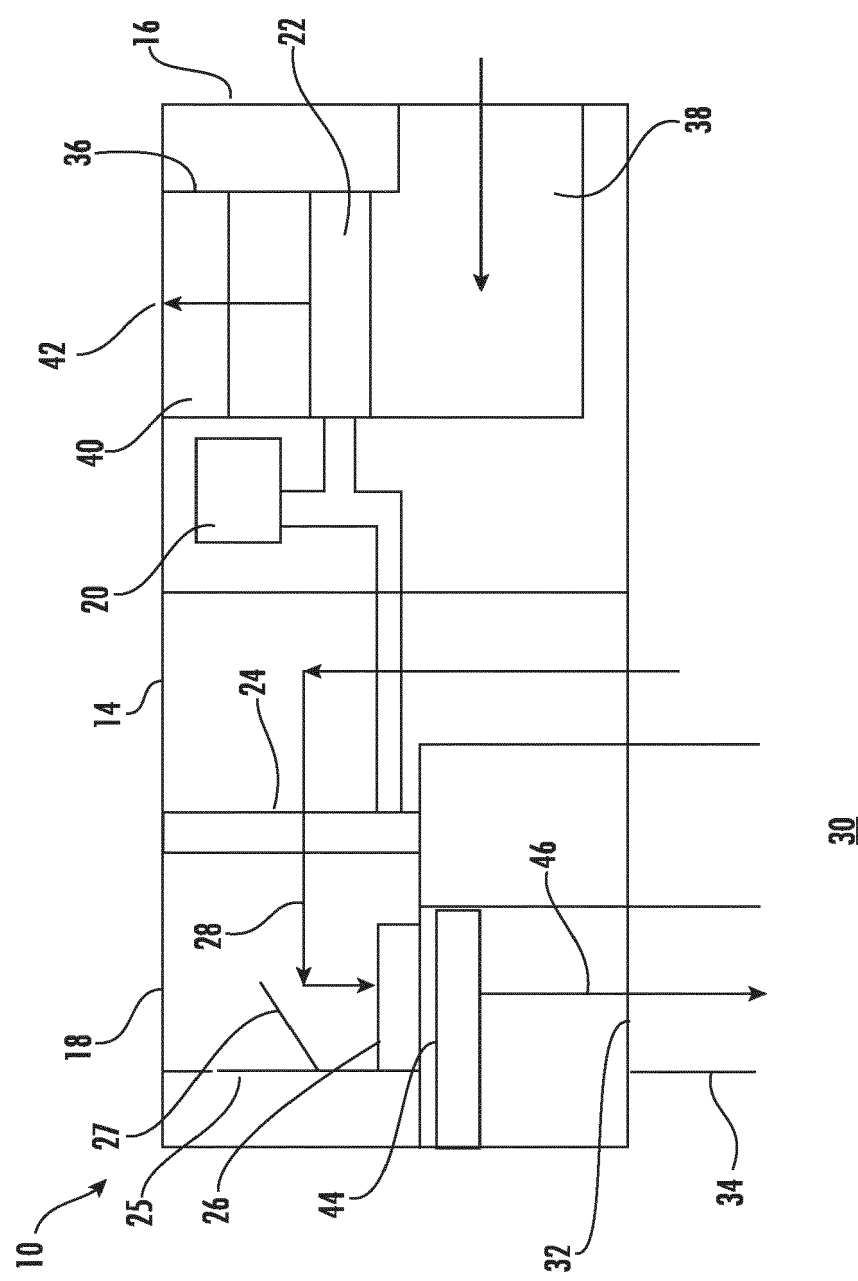


FIG. 1

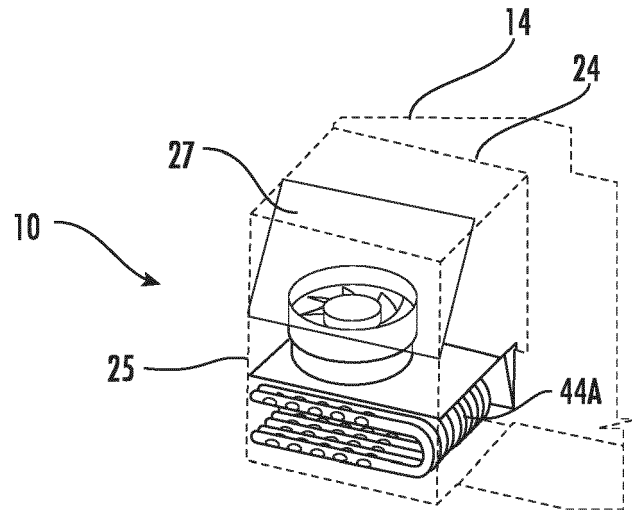


FIG. 2A

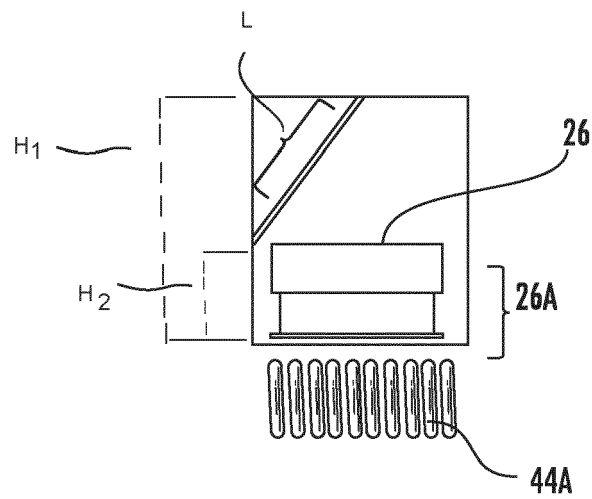


FIG. 2B

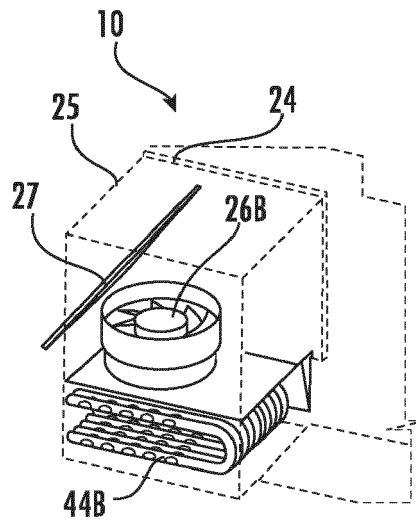


FIG. 3A

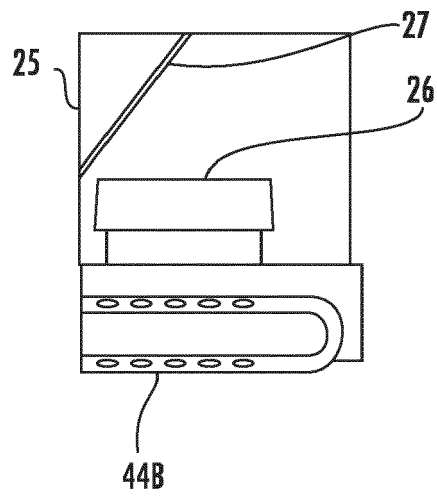


FIG. 3B

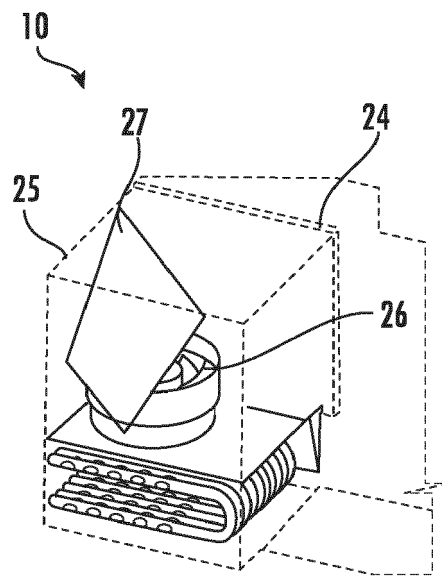


FIG. 4A

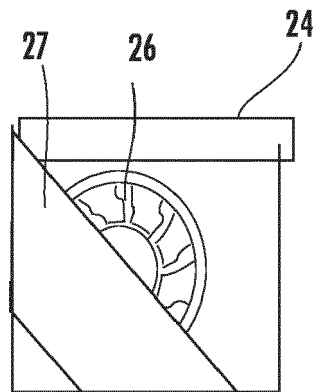


FIG. 4B

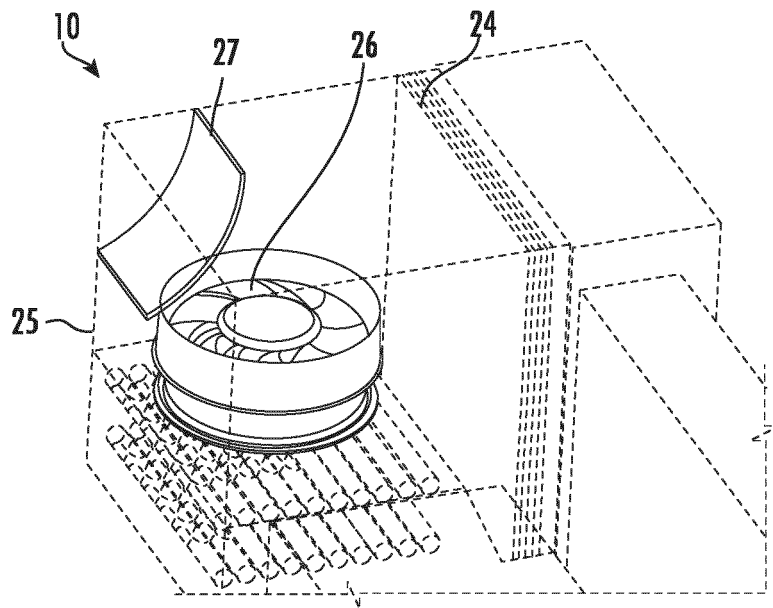


FIG. 5A

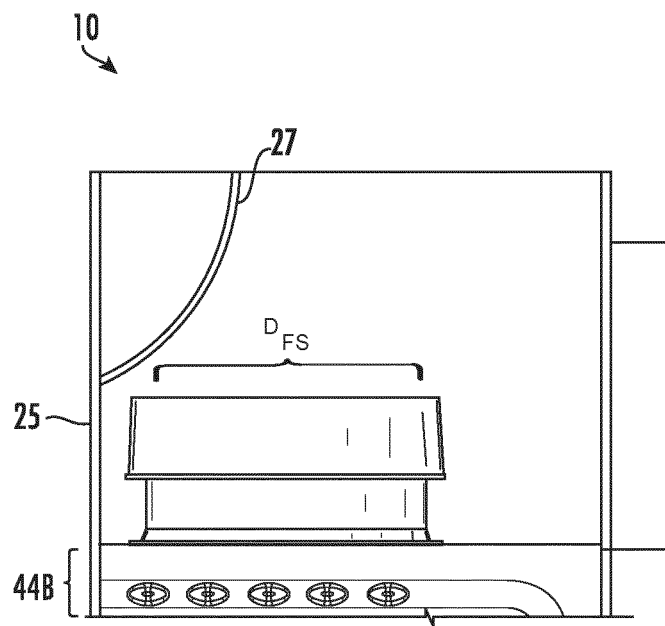


FIG. 5B

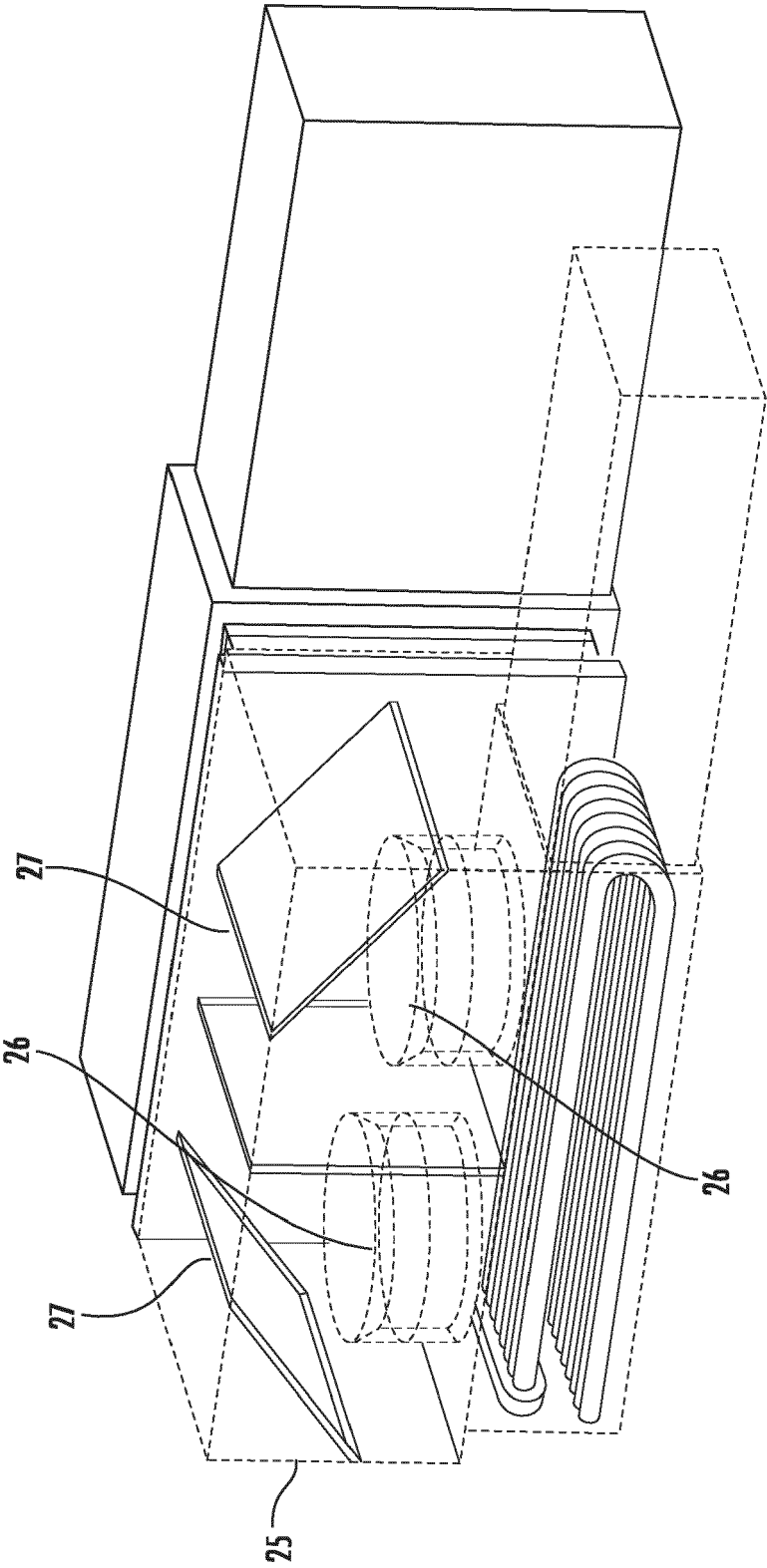


FIG. 6

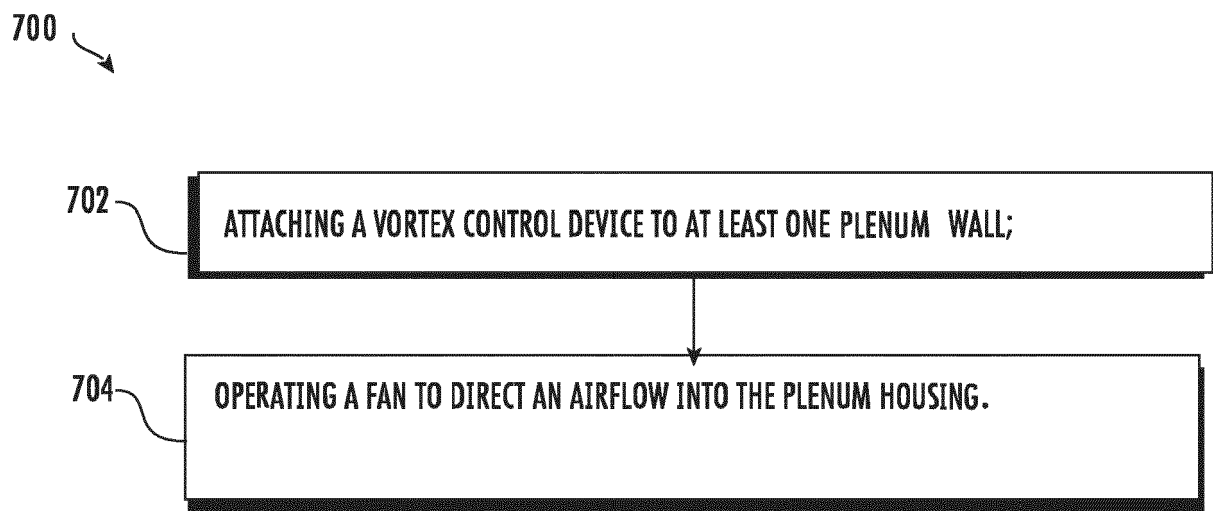


FIG. 7



EUROPEAN SEARCH REPORT

Application Number
EP 21 16 3283

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2008/106526 A1 (JOHNSON CONTROLS TECH CO [US]; RAINEY MELANIE H [US] ET AL.) 4 September 2008 (2008-09-04) * the whole document *	1-6,8-13	INV. F24F1/0022 F24F13/08 F24F13/24
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Y	EP 0 619 461 A2 (DATTA DIPTI [CA]) 12 October 1994 (1994-10-12) * page 4; figures 2,3 *	7,15	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 July 2021	Examiner Blot, Pierre-Edouard
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 21 16 3283

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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