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(54) **Module, device and method for providing a fluid curtain**

Modul, Vorrichtung und Verfahren zur Bereitstellung eines Flüssigkeitvorhangs

Module, dispositif et procédé pour fournir un rideau de fluide

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to a module, method and arrangement for providing a fluid curtain, such as an air curtain, between different environments, such as between two spaces with different temperatures and/or concentrations.

BACKGROUND OF THE INVENTION

[0002] Devices with fluid curtains separating two different environments having common opening interface but different conditions, such as temperature or concentration, are previously known for example in technical fields of refrigeration apparatuses but also a clean work area. The separation barrier is needed to minimize the mixing of different conditions with each other, such as temperature, different types of particles like microbes, concentration or the like. It is noticed that entrained ambient air into the cold air curtain in the refrigeration apparatuses is the largest thermal load of a multi-deck type or "vertical" refrigerated display case and according to some estimates 75% of the refrigeration load comes from the air curtain entrainment. In addition different types of air curtains are also used in laminar air flow work stations, such as is described in US 4,927,438 A.

[0003] As an example the patent publication US 7,162,882 B2 (see Prior Art Figure 1) discloses a multi-band air curtain forming a separation barrier at an interface between a first environment having a fluid at a first condition and a second environment having a fluid at a second condition. A first stream (55) of a fluid is directed along a first path generally parallel to the interface between the first environment and the second environment. A second stream (65) of fluid is directed along a second path generally outwardly at an angle of divergence with the first path. A third stream (85) of a fluid is directed along a third path between the first path and the second path. A refrigerated merchandiser (10) is also disclosed having a display case having an interior defining a product display region (30) having an open front and first (34), second (70) and third (68) air outlets for directing air streams across the open front of the refrigerated merchandiser.

[0004] Additionally a honeycomb structure is disclosed by JP S61 46384 U for providing an air curtain, where the flow or velocity profile is achieved by the honeycomb structure with conduits of different cross sectional areas. Another honeycomb structure is disclosed by JP 2000 102458 A to utilize conduits with different cross sectional areas and thereby providing a refrigerated display case with a multi-band air curtain.

[0005] US 2003/159451 A1 discloses a refrigeration system, where environmental data is obtained and used for controlling the speed of fans to generate an air curtain. The fans are arranged side by side in the width direction of the curtain.

[0006] JP S54 134861 discloses a refrigerating system with a straight and inclined deflecting wall for providing an air curtain. Also JP 2000 102458 A discloses a deflector, which is a convex-shaped.

[0007] There are however some disadvantages relating to the known prior art, such as turbulent transition layer between the air curtain and at least another environment. The more turbulent transition layer the more entrainment of the ambient air into the air curtain occurs. In addition the need of at least two or even more air curtains is clear disadvantage.

SUMMARY OF THE INVENTION

[0008] An object of the invention is to alleviate and eliminate the problems relating to the known prior art. Especially the object of the invention is to provide a method and module for providing a fluid curtain between different environments such as environments with different temperatures, contents and/or concentrations, like bacterial content, so that the entrainment of the ambient fluid into the fluid curtain is minimized.

[0009] The object of the invention can be achieved by the features of independent claims.

[0010] The invention relates to a module according to claim 1. In addition the invention relates to an arrangement of claim 5, and method of claim 6.

[0011] According to an embodiment of the invention a fluid curtain, such as an air curtain, between different environments is provided via a honeycomb structure comprising plurality of parallel conduits. The conduits are configured to laminarize the flow for the fluid curtain, and to guide the flow and suppressing instabilities in the flow downstream of it. The suppressing of instabilities is performed at least in perpendicular direction to walls of said conduits. According to an example the Reynolds number of flow when flowing out from the honeycomb structure is advantageously below 6000, more advantageously below 5000 and most advantageously around 1000. However, it is to be noted that these ranges or values are only examples and that the invention is not limited only to those.

[0012] In addition according to the invention the velocity profile of the flow before the honeycomb structure or during the honeycomb structure is changed so that the velocity profile of the flow after the honeycomb structure is a (advantageously smooth) skewed parabolic velocity profile with a peak shifted from the centre line of the symmetrical parabolic velocity profile. According to an exemplary embodiment the peak is shifted towards the first environment, such as towards inside of the refrigerated display case.

[0013] The invention offers clear advantages over the known prior art, when the inventors have noticed that the shape of vertical velocity profile and the turbulence intensity present at the outlet nozzle will remarkably control the fluid curtain entrainment rate. For example when ap-

plying the velocity profile as proposed by the present invention the relative velocity and change of relative velocity in the transition layer with the second environment fluid (such as warm ambient air) is small, which keeps the transition layer with the second environment fluid as laminar as possible thereby minimizing entrainment of the ambient fluid into the fluid curtain. By minimizing the entrainment of the ambient fluid the thermal or particle load of the systems and thereby the refrigeration or cleaning costs of the display case can be remarkable reduced.

[0014] The term entrainment is used in this document for example to the purpose of to transfer air or other fluid (or even particles) into an organized fluid current (such as an air curtain) from the surrounding atmosphere.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Next the invention will be described in greater detail with reference to exemplary embodiments in accordance with the accompanying drawings, in which:

Figure 1 illustrates a prior art device for providing air curtains,

Figure 2 illustrates an exemplary module for providing fluid curtain according to an advantageous embodiment of the invention, and

Figure 3 illustrates an exemplary arrangement (a refrigerated display case) for providing fluid curtain according to an advantageous embodiment of the invention.

DETAILED DESCRIPTION

[0016] Figure 1 illustrates a prior art device for providing air curtains described in US 7,162,882 B2. Figure 1 is already handled in connection with the background of the invention chapter above. Anyway it is to be understood that the module and inventive concept of the present invention can also be implemented with similar devices as described in Figure 1, where the air curtain providing means can be replaced for example by the module of the invention described in Figure 2 or with the means of said module, such as an appropriate mechanical structure before the outlet for the air curtain, where said mechanical structure is configured to change the velocity profile of the flow before the honeycomb structure or during the honeycomb structure so that the velocity profile of the flow after the honeycomb structure or outlet is a smooth skewed parabolic velocity profile with a peak shifted from the centre line of the symmetrical parabolic velocity profile.

[0017] Figure 2 illustrates an exemplary module 100 for providing a fluid curtain, and especially an air curtain 101 between different environments (Environment I, Environment II) according to an advantageous embodiment of the invention, where the module comprises a flow channel 102. The module 100 comprises an inlet 103 for introducing an air flow through the flow channel of the module and an outlet 104 for outputting said air curtain. In addition the module 100 comprises a honeycomb structure 105 before the outlet in order to laminarize the flow for the air curtain. The honeycomb structure comprises plurality of parallel conduits 106 for guiding the flow and suppressing instabilities in the flow downstream of it and at least in perpendicular direction to walls of said conduits 106.

[0018] In addition the module 100 comprises a mechanical structure 105, 107 before the outlet 104, which is configured to change the velocity profile of the flow 101 before 107 the honeycomb structure or during 105 the honeycomb structure so that the velocity profile of the flow after the honeycomb structure 105 or outlet 104 is a smooth skewed parabolic velocity profile with a peak 108 shifted from the centre line 109 of the symmetrical parabolic velocity profile or the centre line 109 of the honeycomb structure 105.

[0019] According to the invention the mechanical structure before the outlet is a deflector 107, such as an S-shaped (described in Figure 2) . The deflector 107 is configured to guide the air flow 110 from the inlet 103 to the honeycomb structure 105 so that greater dynamic pressure and thereby the greater fluid velocity is introduced to the distance from the centre line 109 of the honeycomb structure, and most advantageously so that the greater dynamic pressure and thereby greater fluid velocity is introduced to the point before the centre line 109 of the honeycomb structure in the direction of the inlet flow 103.

[0020] According to an embodiment the form of the deflector 107 in the downstream direction 110 of the inlet flow is convergent, advantageously continuously convergent, and most advantageously continuously but nonlinearly convergent towards the honeycomb structure 105. Due to the rounded shapes and smooth surface of the deflector 107 it does not significantly generate turbulence in flow upstream of the honeycomb structure 105, In addition the honeycomb structure 105 itself is a very effective device to suppress the fluid curtain instabilities immediately downstream of it.

[0021] In addition according to an embodiment the first curve 107a of the S-shaped deflector 107 or the peak or apex of the convex-shaped deflector (not shown) is configured to protrude towards the honeycomb structure 105 is located in the downstream direction of the inlet flow 110 before the centre line 109 of the honeycomb structure 105. Furthermore, according to an embodiment the second curve 107b of the S-shaped deflector 107 is configured to protrude into the opposite direction than the first curve, and is located in the downstream direction of the inlet flow 110 after the centre line 109 of the honeycomb structure 105. According to these embodiment the greater dynamic pressure and thereby the greater fluid velocity can be introduced to the point before the centre line 109 of the honeycomb structure in the direction of the inlet

flow 103, and thereby the smooth skewed parabolic velocity profile with a peak 108 shifted from the centre line 109 of the symmetrical parabolic velocity profile or the centre line 109 of the honeycomb structure 105 can be achieved, as is described in Figure 2.

[0022] Figure 3 illustrates an exemplary arrangement 200, such as a refrigerated display case, for providing fluid curtain according to an advantageous embodiment of the invention. The device may comprise a display space 201, an access opening 202 in the front of said display space, and a flow curtain providing means 100 for establishing the flow curtain 101 across the access opening 202. Even if the refrigerated display case is described here as an example, it is to be noted that the inventive concept, namely the module 100 or the means and features 101-110 of the module described e.g. in Figure 2 can be utilized also in other devices separating at least two different environments with the fluid curtain, such as laminar air flow work stations.

[0023] The refrigerated display case 200 described in Figure 3 comprises only one means for producing the fluid curtain, such as only one channel 102, and therefore only one fluid curtain 101. In addition the device 200 comprises a fluid suction means or portion 203 located adjacent the lower edge of the access opening 202, an air duct 204 communicating with said fluid suction means or portion 203 having a fluid discharge outlet 205 near the upper edge of the access opening 202.

[0024] The deflector 107 and the honeycomb structure 105, 106 described e.g. in connection with Figure 2 can be implemented in connection with the fluid discharge opening 205 to provide the fluid curtain 101. However, it is to be noted that the deflector 107 and the honeycomb structure 105, 106 described e.g. in connection with Figure 2 can also be implemented into the device described in Figures 1 or 3 as a module described e.g. in connection with Figure 2.

[0025] In addition the device 200 advantageously comprises circulating means 206 for circulating fluid through said fluid duct 204, 205 and again through the deflector 107 and the honeycomb structure 105, 106, as well as through the refrigeration means 207 for example for refrigerating the fluid for the fluid curtain 101.

[0026] The device 200 described in Figure 3 is a recirculated type refrigerated display case, since it comprises the fluid suction means or portion 203 for collecting the chilled fluid of the fluid curtain 101 and recirculating it again. However, the inventive concept and embodiments of the present invention can also be implemented in connection with non-recirculated type devices, such as is described in Figure 1, where the refrigerated display case comprises also one or more fans 72 or the like to draw ambient air from the environment exterior of the refrigerator 10 through the fluid duct 74 to the second air discharge outlet 70.

[0027] According to an advantageous embodiment the flow curtain 101 is created by forcing chilled flow in the duct 205 at the top of the display case 200 into the deflector 107, such as S-shaped deflector. The deflector 107 turns the chilled fluid flow 110 downward through the honeycomb structure 105 and thereby produces a smooth skewed parabolic velocity profile with peak shifted towards the inside of the display case 200 having low temperature (Environment I) compared to the ambient temperature (Environment II). The invention has been explained above with reference to the aforementioned embodiments, and several advantages of the invention have been demonstrated. It is clear that the invention is not only restricted to these embodiments, but comprises all possible embodiments within the scope of the following patent claims. For example the different environments separated by the fluid curtain comprise different conditions, such as temperatures, bacterial contents, humidity, concentration or the like.

Claims

1. A module (100) for providing a fluid curtain (101), such as an air curtain, between different environments, the module forming a flow channel (102), the module comprising

   - an inlet (103) for introducing an air flow through said flow channel (102) of the module,
   - an outlet (104) for introducing said air curtain,
   - honeycomb structure (105) before the outlet (104) in order to laminarize the flow for the fluid curtain, where said honeycomb structure comprises plurality of parallel conduits (106) for guiding the flow and suppressing instabilities in the flow downstream of it, and
   - a mechanical structure before the outlet (104),

   characterized in that

   - said mechanical structure before the outlet is an S-shaped deflector (107), which is configured to guide the air flow from the inlet (103) to the honeycomb structure (105) so that greater dynamic pressure and thereby greater fluid velocity is introduced to the distance from the centre line (109) of the honeycomb structure, and thereby configured to change the velocity profile of the flow before the honeycomb structure so that the velocity profile of the flow after the honeycomb structure (105) or outlet (104) is a skewed parabolic velocity profile with a peak (108) shifted from the centre line (109) of the symmetrical parabolic velocity profile.

2. A module of claim 1, wherein the form of the deflector (107) in the downstream direction of the inlet flow is convergent, advantageously continuously convergent, and most advantageously continuously but nonlinearly convergent towards said honeycomb

structure (105).

3. A module of claim 2, wherein the first curve (107a) of the S-shaped deflector or the peak or apex of the convex-shaped deflector towards said honeycomb structure (105) is located in the downstream direction of the inlet flow before the centre line (109) of the honeycomb structure.

4. A module of claim 2 or 3, wherein the second curve (107b) of the S-shaped deflector into the opposite direction than said first curve is located in the downstream direction of the inlet flow after the centre line (109) of the honeycomb structure.

5. An arrangement (10, 200), such as a refrigerated display device, comprising a display space (201), an access opening (202) in the front of said display space, a fluid curtain (101), such as an air curtain providing means with a flow channel (102) for establishing said curtain across said access opening (202),
characterized in that the device comprises:

the module (100) according to any of claim 1-4 for providing said fluid curtain (101).

6. Method for providing a fluid curtain (101), such as an air curtain between different environments, comprising the steps of

- introducing an air flow (110) into an inlet (103) of fluid curtain providing means (102-109),
- laminarizing the air flow for the fluid curtain via a honeycomb structure (105) comprising plurality of parallel conduits (106) for guiding the flow and suppressing instabilities in the flow downstream of it and before an outlet (104), and

characterized in that the method further comprises:

- changing the velocity profile of the flow before the honeycomb structure by a mechanical structure, which is an S-shaped deflector (107), which guides the fluid flow from the inlet (103) to the honeycomb structure (105) so that greater dynamic pressure and thereby greater fluid velocity is introduced to the distance from the centre line (109) of the honeycomb structure, and thereby changes the velocity profile of the flow before the honeycomb structure so that the velocity profile of the flow after the honeycomb structure (105) or outlet (104) is a skewed parabolic velocity profile with a peak (108) shifted from the centre line (109) of the symmetrical parabolic velocity profile.

Patentansprüche

1. Modul (100) zur Bereitstellung eines Fluidvorhangs (101), wie eines Luftvorhangs, zwischen verschiedenen Umgebungen, wobei das Modul einen Strömungskanal (102) bildet, wobei das Modul umfasst:

- einen Einlass (103) zum Einbringen eines Luftstroms durch den Strömungskanal (102) des Moduls,
- einen Auslass (104) zum Einbringen des Luftvorhangs,
- eine Wabenstruktur (105) vor dem Auslass (104), um den Strom für den Fluidvorhang zu laminarisieren, wobei die Wabenstruktur mehrere parallele Leitungen (106) zum Führen des Stroms und Unterdrücken von Instabilitäten im Strom stromabwärts davon umfasst, und
- eine mechanische Struktur vor dem Auslass (104),

dadurch gekennzeichnet, dass

- die mechanische Struktur vor dem Auslass ein S-förmiger Ablenker (107) ist, der ausgelegt ist, den Luftstrom vom Einlass (103) zur Wabenstruktur (105) zu führen, so dass ein größerer dynamischer Druck und dadurch eine größere Fluidgeschwindigkeit in die Distanz von der Mittellinie (109) der Wabenstruktur eingebracht werden, und dadurch ausgelegt ist, das Geschwindigkeitsprofil des Stroms vor der Wabenstruktur zu ändern, so dass das Geschwindigkeitsprofil des Stroms nach der Wabenstruktur (105) oder dem Auslass (104) ein schräges parabolisches Geschwindigkeitsprofil mit einer Spitze (108) ist, die von der Mittellinie (109) des symmetrischen parabolischen Geschwindigkeitsprofils verschoben ist.

2. Modul nach Anspruch 1, wobei die Form des Ablenkers (107) in der stromabwärtigen Richtung des Einlassstroms konvergierend ist, vorteilhaft kontinuierlich konvergierend, und am vorteilhaftesten kontinuierlich, jedoch nicht-linear konvergierend zur Wabenstruktur (105).

3. Modul nach Anspruch 2, wobei die erste Krümmung (107a) des S-förmigen Ablenkers oder die Spitze oder der Scheitel des konvexförmigen Ablenkers zur Wabenstruktur (105) in der stromabwärtigen Richtung des Einlassstroms vor der Mittellinie (109) der Wabenstruktur angeordnet ist.

4. Modul nach Anspruch 2 oder 3, wobei die zweite Krümmung (107b) des S-förmigen Ablenkers in der zur ersten Kurve entgegengesetzten Richtung in der stromabwärtigen Richtung des Einlassstroms vor

der Mittellinie (109) der Wabenstruktur angeordnet ist.

5. Anordnung (10, 200), wie eine gekühlte Anzeigevorrichtung, umfassend einen Anzeigeraum (201), eine Zugangsöffnung (202) vor dem Anzeigeraum, einen Fluidvorhang (101), wie ein Luftvorhang-Bereitstellungsmittel mit einem Strömungskanal (102) zur Herstellung des Vorhangs quer über die Zugangsöffnung (202),
dadurch gekennzeichnet, dass die Vorrichtung umfasst:

das Modul (100) nach einem der Ansprüche 1 bis 4 zur Bereitstellung des Fluidvorhangs (101).

6. Verfahren zur Bereitstellung eines Fluidvorhangs (101), wie eines Luftvorhangs zwischen verschiedenen Umgebungen, umfassend die Schritte:

- Einbringen eines Luftstroms (110) in einen Einlass (103) von Fluidvorhang-Bereitstellungsmitteln (102 bis 109),
- Laminarisieren des Luftstroms für den Luftvorhang über eine Wabenstruktur (105), umfassend mehrere parallele Leitungen (106) zum Führen des Stroms und Unterdrücken von Instabilitäten im Strom stromabwärts davon und vor einem Auslass (104), und

dadurch gekennzeichnet, dass das Verfahren ferner umfasst:

- Ändern des Geschwindigkeitsprofils des Stroms vor der Wabenstruktur durch eine mechanische Struktur, die ein S-förmiger Ablenker (107) ist, der den Fluidstrom vom Einlass (103) zur Wabenstruktur (105) führt, so dass ein größerer dynamischer Druck und dadurch eine größere Fluidgeschwindigkeit in die Distanz von der Mittellinie (109) der Wabenstruktur eingebracht werden, und dadurch das Geschwindigkeitsprofil des Stroms vor der Wabenstruktur ändert, so dass das Geschwindigkeitsprofil des Stroms nach der Wabenstruktur (105) oder dem Auslass (104) ein schräges parabolisches Geschwindigkeitsprofil mit einer Spitze (108) ist, die von der Mittellinie (109) des symmetrischen parabolischen Geschwindigkeitsprofils verschoben ist.

Revendications

1. Module (100) de création d'un rideau de fluide (101) comme un rideau d'air, entre différents environnements, ce module formant un canal d'écoulement (102), ce module comprenant

- une entrée (103) pour introduire un flux d'air à travers ledit canal d'écoulement (102) du module,
- une sortie (104) pour introduire ledit rideau d'air,
- une structure en nid d'abeilles (105) avant la sortie (104) afin de lamininariser l'écoulement pour le rideau de fluide, ladite structure en nid d'abeilles comprenant une pluralité de conduites parallèles (106) pour guider l'écoulement et supprimer les instabilités dans l'écoulement en aval de celui-ci,
- une structure mécanique avant la sortie (104),

caractérisé en ce que

- ladite structure mécanique avant la sortie est un déflecteur en forme de S (107) qui est conçu pour guider le flux d'air depuis l'entrée (103) jusqu'à la structure en nid d'abeilles (105) afin qu'une plus forte pression dynamique et ainsi une plus haute vitesse du fluide soit introduite dans la distance entre la ligne centrale (109) et la structure en nid d'abeilles, et ainsi conçu pour changer le profil de vitesse de l'écoulement avant la structure en nid d'abeilles afin que le profil de vitesse de l'écoulement après la structure en nid d'abeilles (105) ou la sortie (104) soit un profil de vitesse parabolique asymétrique avec une crête (108) décalée de la ligne centrale (109) du profil de vitesse parabolique symétrique.

2. Module selon la revendication 1, dans lequel la forme du déflecteur (107), dans le sens dirigé vers l'aval de l'écoulement d'entrée, est convergente, avantageusement continûment convergente, et le plus avantageusement continûment mais non linéairement convergents en direction de ladite structure en nid d'abeilles (105).

3. Module selon la revendication 2, dans lequel la première courbe (107a) du déflecteur en forme de S ou la crête ou l'apex du déflecteur de forme convexe en direction de ladite structure d'abeilles (105) se situe dans le sens dirigé vers l'aval de l'écoulement d'entrée avant la ligne centrale (109) de la structure en nid d'abeilles.

4. Module selon la revendication 2 ou 3, dans lequel la seconde courbe (107b) du déflecteur en forme de S dans le sens opposé à ladite première courbe se situe dans le sens dirigé vers l'aval de l'écoulement d'entrée après la ligne centrale (109) de la structure en nid d'abeilles.

5. Agencement (10, 200), tel qu'un dispositif de présentation réfrigéré, comprenant un espace de pré-

sentation (201), une ouverture d'accès (202) sur le devant dudit espace de présentation, un rideau de fluide (101), comme un rideau d'air, fournissant avec un canal d'écoulement (102) un moyen d'établissement dudit rideau en travers de ladite ouverture d'accès (202),
caractérisé en ce que le dispositif comprend :

le module (100) selon l'une quelconque des revendications 1 à 4 de création dudit rideau de fluide (101).

6. Procédé de création d'un rideau de fluide (101), comme un rideau d'air, entre différents environnements, comprenant les étapes suivantes :

- introduction d'un flux d'air (110) dans une entrée (103) d'un moyen de création de rideau de fluide (102-109),
- laminarisation du flux d'air pour le rideau de fluide par l'intermédiaire d'une structure en nid d'abeilles (105) comprenant une pluralité de conduites parallèles (106) pour guider le flux et supprimer les instabilités dans le flux en aval de celui-ci et avant une sortie (104), et

caractérisé en ce que ce procédé comprend en outre :

- la modification du profil de vitesse de l'écoulement avant la structure en nid d'abeilles par une structure mécanique qui est un déflecteur en forme de S (107) qui guide l'écoulement de fluide depuis l'entrée (103) jusqu'à la structure en nid d'abeilles (105) afin qu'une plus forte pression dynamique et ainsi une plus haute vitesse d'écoulement soit introduite dans la distance depuis la ligne centrale (109) jusqu'à la structure en abeilles, et modifie ainsi le profil de vitesse de l'écoulement avant la structure en nid d'abeilles pour que le profil de vitesse de l'écoulement après la structure en nid d'abeilles (105) ou la sortie (104) soit un profil de vitesse parabolique asymétrique avec une crête (108) décalée de la ligne centrale (109) du profil de vitesse parabolique symétrique.

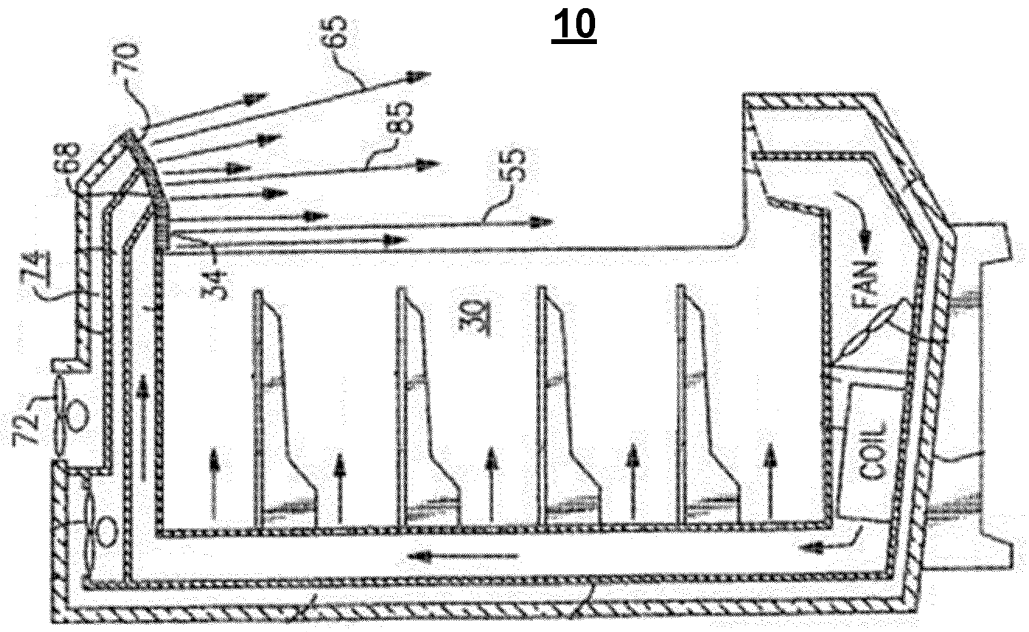
10
70
65
85
68
55
74
34
30
FAN
72
COIL

FIG. 1

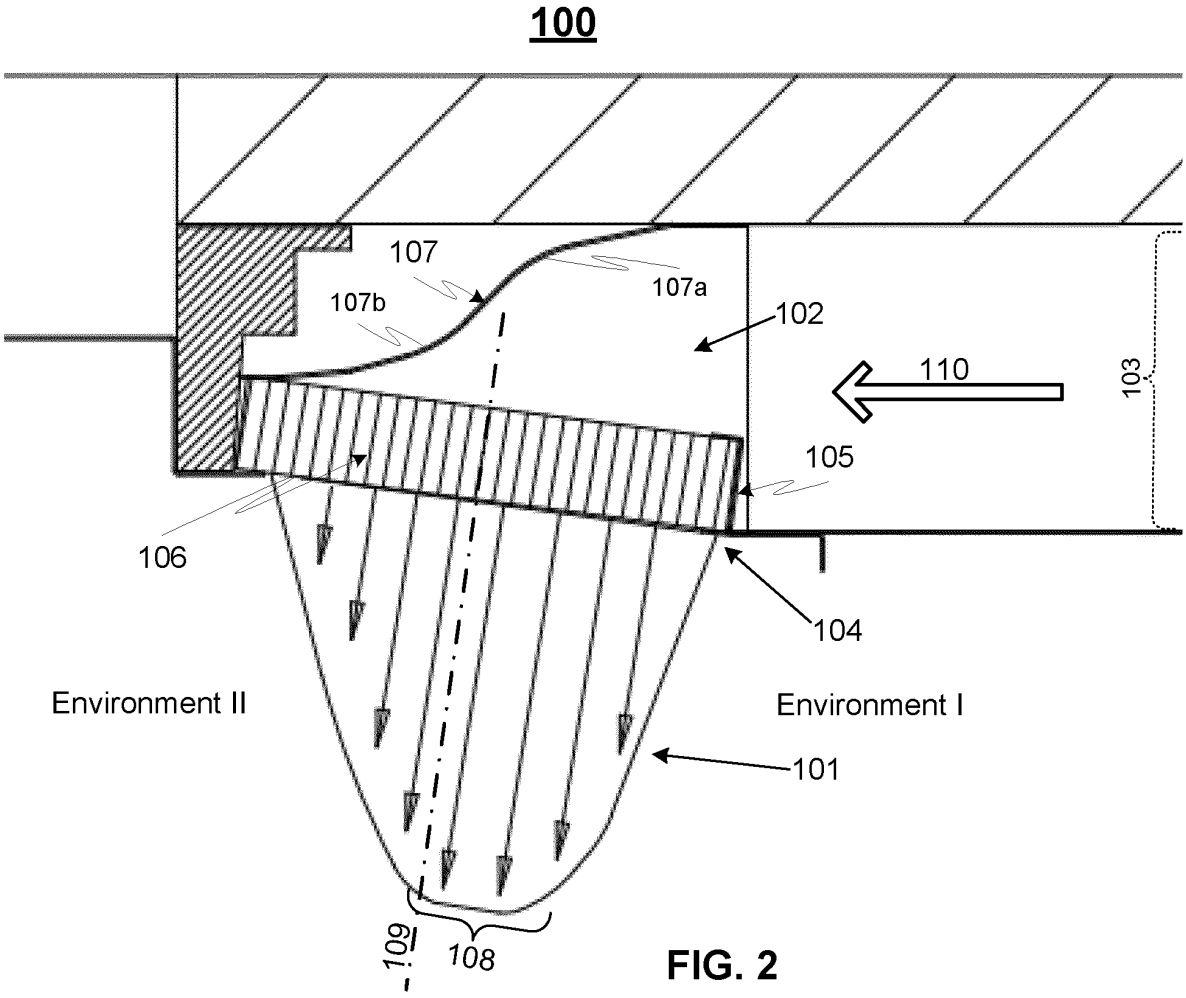
100
107
107b
107a
102
110
103
105
106
104
Environment II
Environment I
101
109
108

FIG. 2

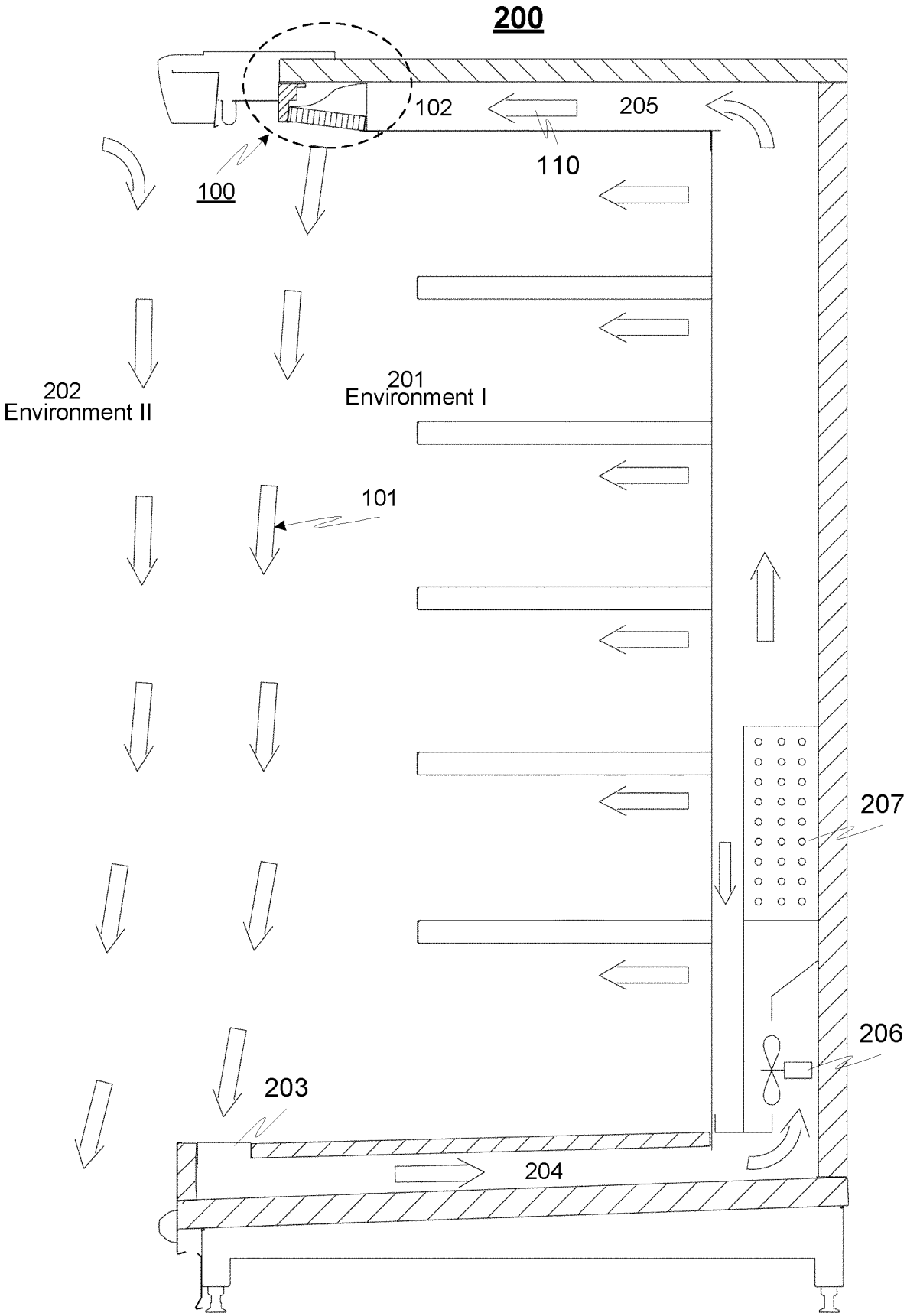
200
102
205
110
100
202
Environment II
201
Environment I
101
207
206
203
204

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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